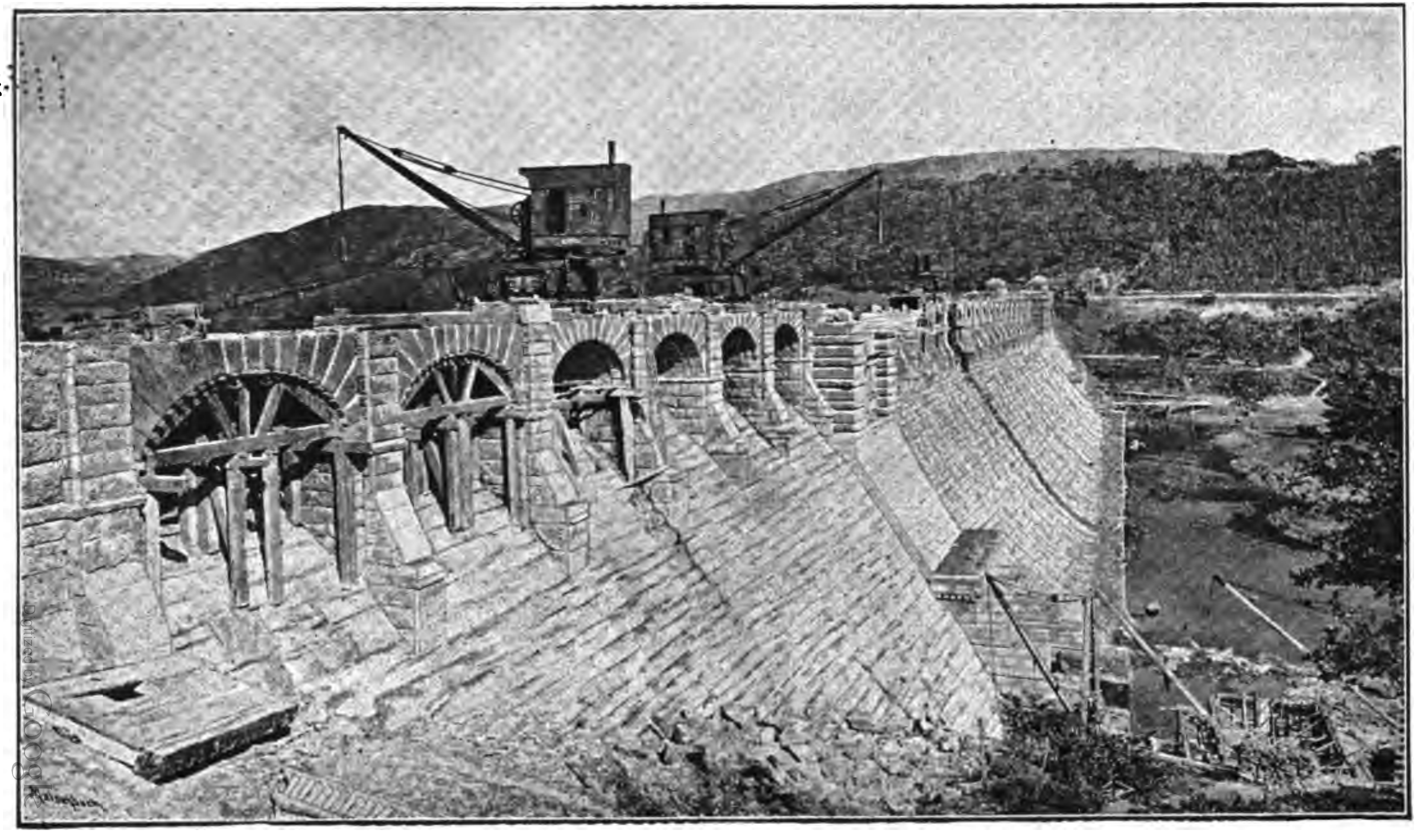

Frontispiece.

THE VYRNWY DAM (*see p. 6*).

Institution of municipal & county engineers, Lond.

PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME XV.—1888-89.

EDITED BY

THOMAS COLE,

ASSOC. M. INST. C.E.

(*Secretary of the Association*).

The Association is not as a body responsible for the facts and opinions advanced herein.

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ERRATUM.

Page 59, line 5 from bottom, *for* "July" *read* "June."

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PHILLIPS, R.	County Surveyor, Gloucester.
PICKERING, RICHARD	11, Lowther Street, Whitehaven.
PILDITCH, J. T.	Surveyor to the Parish of Battersea.
PLATT, S. S., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Rochdale; *Hon. Secretary* Lancashire and Cheshire District.
POLLARD, J., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Hendon. 7, Gt. Queen Street, Westminster.
PORTER, R.	Borough Surveyor, Wakefield.
POWELL, D. H. W...	Town Surveyor, Pontypool.
PRICE, JOHN, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Toxteth Park, Liverpool.
PRITCHARD, EDWARD, M. Inst. C.E. (*Past President.*)	37, Waterloo Street, Birmingham; and 2, Storey's Gate, S.W.
PROCTOR, J., M. Inst. C.E. ..	13, Mawdesley Street, Bolton, Lancashire.
PURNELL, E. J.	City Surveyor, Coventry, Warwickshire.
RADFORD, J. C., Assoc. M. Inst. C.E.	District Surveyor, Putney.
RAMSDEN, A.	Surveyor to the Local Board, Chiswick.
RAPLEY, WM., jun.	Surveyor to the Dorking Rural Sanitary Authority.
READ, RICHARD, Assoc. M Inst. C.E.	City Surveyor, Gloucester.
RICHARDS, R. W.	City Surveyor, Sydney, N.S.W.
RICHARDSON, JAS., Assoc. M. Inst. C.E.	Urban Sanitary Authority, Stamford.
RICHARDSON, H.	Surveyor to the Local Board, Oldbury.
ROBINSON, W. J., Assoc. M. Inst. C.E.	City Surveyor, Londonderry.
ROBSON, O. C., Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Local Board, Willesden, Middlesex; *Hon. Secretary*, Home Counties District.
ROSS, P.	Surveyor to the Local Board, North Bierley.
ROTHWELL, E.	Tramways Co., Rochdale.
ROUNTHWAITE, R. S.	Borough Engineer, Sunderland.
ROWE, WM.	Tiverton, Devon.
ROYLE, H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Stretford, Lancashire.
RUCK, F. W.	County Surveyor, Kent. Maidstone.
SADLER, G. W.	Surveyor to the Sanitary Authority, Cheltenham.
SASSE, G. H.	Surveyor, Clacton-on-Sea.

SAVAGE, WM. HY.	Surveyor to the Local Board, East Ham.
SCOTT, H. H., Assoc. M.I.C.E.	Engineer to the Commissioners, Hove.
SCOTT, R. S.	Surveyor to the Local Board, Bishop's Stortford.
SHARMAN, E.	Surveyor to the Local Board, Wellingborough, Northamptonshire.
SHEPPARD, GEO.	Borough Surveyor, Newark.
SHUTTLEWORTH, F. H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Littleborough, Lancashire.
SIDDONS, J. M.	Town Surveyor, Oundle.
SILCOCK, E. J., A. M.Inst.C.E.	Borough Surveyor, King's Lynn.
SIMPSON, J.	Quadrant Chambers, Buxton.
SMITH, G. F.	Surveyor to the Local Board, Milverton, Warwickshire.
SMITH, J. W. M. .. .. .. (*Member of Council.*)	Borough Surveyor, Wrexham, Denbighshire; *Hon. Secretary*, Wales District.
SMYTHE, F.	Local Board, Finchley, N.
SOUTHAM, A., A.M.I.C.E. ..	Surveyor, Clapham, London, S.W.
SPENCER, J. P., A.M.Inst.C.E.	50, Side, Newcastle-on-Tyne.
SPINKS, W., Assoc.M.Inst.C.E.	Surveyor to the Local Board, Dukinfield.
ST. GEORGE, PERCIVAL, M.Inst. C.E.	City Engineer, Montreal, Canada.
STAFFORD, J. E., Assoc. M. Inst. C.E.	Late Borough Engineer, Burnley.
STAINTHORPE, T. W.	Surveyor to the Eston District Local Board, Yorkshire.
STANSFIELD-BRUN, J., Assoc. M. Inst. C.E.	Town Surveyor, Bradford, Wilts.
STEPHENS, R. J.	Surveyor to the Local Board, Belgrave, Leicester.
STEVENS, GEORGE	Brook Cottage, Blaina, Mon.
STEWART, A.	Surveyor to the Rural Sanitary Authority, Maldon, Essex.
STEWART, WM.	Surveyor to the Local Board, Rugby.
STOKOE, J.	Surveyor to the Local Board, Altrincham.
STRACHAN, G. R., Assoc. M. Inst. C.E.	Late Surveyor, Chelsea.
STRACHAN, J. H.	Surveyor to the Local Board, Brentford.
STRINGFELLOW, H. W.	City Surveyor, Chichester.
STUART, J. C.	Surveyor to the Local Board, Smethwick.
STUBBS, WM., Assoc. M. Inst. C.E.	Borough Surveyor, Over Darwen.
SWARBRICK, JOSEPH, Assoc. M. Inst. C.E.	44, Brasenose Street, Albert Sq., Manchester.
SWINDLEHURST, J. E., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Rawtenstall.
SYKES, ED., A.M.I.C.E. ..	Surveyor to the Local Board, Cheadle, Manchester.
TANNER, W.	County Surveyor, Monmouthshire. Newport.
TAYLOR, H., A. M. Inst. C.E.	Surveyor to the Local Board, Clevedon, Somerset.
THOMAS, JOHN	Surveyor to the Rural Sanitary Authority, Swansea.
THOMAS, W.	Surveyor to the Margam Local Board, Porttalbot, S. Wales.
THOMAS, W., Assoc.M.Inst.C.E.	Borough Surveyor, Dover.
THOMAS, W. E. C., Assoc. M. Inst. C.E.	Surveyor to the Rural Sanitary Authority, Neath.
THOMPSON, R.	Surveyor to the Local Board, Waterloo, near Liverpool.
THORBURN, T. C.	Borough Surveyor, Birkenhead.
THORROLD, S. E.	Surveyor to the Local Board, Redditch.
TILL, W. S., M. Inst. C.E... (*Past President.*)	Borough Engineer, Birmingham.
TOMES, C.	Borough Surveyor, Eastbourne.

TRAPP, S. C.	88, Mosley Street, Manchester.
TUDOR, E. C. B.	Surveyor to the Local Board, Goole, Yorkshire.
TURNER, L.	Surveyor to the Rural Sanitary Authority, Headington, Oxford. 18, James St., Oxford.
VALLANCE, R. F.	Town Surveyor, Mansfield.
VALON, W. A. McINTOSH, Assoc. M.I.C.E.	Ramsgate Corporation Gas Works Engineer.
VENTRIS, A., Assoc. M. Inst. C.E.	Surveyor to the Strand District Board of Works. 5, Tavistock Street, Covent Garden.
WAKELAM, H. T., A.M.I.C.E.	Surveyor to the Local Board, Garston.
WALLACE, G.	Surveyor to St. Giles District Board of Works.
WALKER, C. L., Assoc.M.Inst. C.E.	Surveyor to the Local Board, Wood Green.
WALKER, T., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Croydon, Surrey.
WALLIS, T. W.	Borough Surveyor, Louth.
WALSHAW, J. W.	Borough Surveyor, Peterborough.
WARDLE, J. W., Assoc. M. Inst. C.E.	Borough Surveyor, Longton.
WATSON, J. D., Assoc. M. Inst. C.E.	Burgh Surveyor, Arbroath, N.B.
WATTS, E. T.	Surveyor to the Rural Sanitary Authority, Bishop's Stortford.
WAYE, H.	Surveyor to the Local Board, Millom, Cumberland.
WEAVER, WM., Assoc. M. Inst. C.E.	Surveyor to the Vestry, Kensington.
WEBSTER, J. L.	Borough Surveyor, Malton.
WELBURN, W...	Borough Surveyor, Middleton, near Manchester.
WESTON, GEO.	Surveyor to the Vestry, Paddington.
WESTON, H. J., Assoc. M.I.C.E.	Surveyor to the Local Board, Shirley and Freemantle, Southampton.
WHEELER, G. R. W., Assoc. M. Inst. C.E.	Surveyor, Westminster.
WHEELER, W. H., M. Inst. C.E.	Borough Surveyor, Boston, Lincolnshire.
WHITE, A. E., Assoc.M.Inst.C.E.	Borough Engineer, Hull.
WHITE, W. H., M. Inst. C.E. (*Past President.*)	Engineer to the Local Board, Oxford.
WHITLOW, HENRY	Surveyor to the Local Board, Ulverston.
WIKE, C. F., Assoc. M.I.C.E.	Borough Engineer, Sheffield.
WILD, G. H.	Surveyor to Local Board, Wuerdle and Wardle, Lancashire.
WILDS, W. H...	Borough Engineer, Hertford.
WILKINSON, J. P., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Newton Heath, near Manchester.
WILLCOX, J. E., Assoc. M. Inst. C.E.	118, Colmore Row, Birmingham.
WILLSON, J.	Surveyor to the Local Board, Ashford, Kent.
WILSON, GEOFFREY	Surveyor to the Local Board, Alnwick.
WILSON, J. B...	Court House, Cockermouth.
WILSON, J.	Borough Surveyor, Bacup, Lancashire.
WILSON, WILLIAM	Surveyor to the District Local Board, Dalton-in-Furness.
WINDOW, E.R., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Bishop's Stortford. 2, Fairfield Street, Prescot St., Liverpool.
WINSHIP, G., A. M. Inst. C.E.	Borough Surveyor, Abingdon, Berks.
WITTS, J. W...	Town Surveyor, Skelton in Cleveland.
WOLSTENHOLME, J., Assoc. M. Inst. C.E.	Borough Surveyor, Blackpool.

WOOD, A. R.	Surveyor to the Local Board, Tunstall.
WOOD, H. C.	Surveyor to the Parish of Tooting. 1, Great James St., Bedford Row.
WOODBRIDGE, C. A.	Surveyor to the Local Board, Pinner.
WORSWICK, R. A.	Surveyor to the Local Board, Saltburn-by-the-Sea.
WORTH, J. E., Assoc. M. Inst. C.E.	Engineer to the Local Board, Tottenham.
WRIGHT, J.	Borough Surveyor, Macclesfield, Cheshire.
WYATT, W. J.	Surveyor to the Local Board, Paignton, Devon.

GRADUATES.

BALL, GEO.	Borough Surveyor's Office, Scarborough.
BARNES, S. W. J.	Local Board Offices, Ealing, W.
BLIZARD, J. H.	Lansdowne House, Southampton.
BRADLEY, J. W.	Borough Surveyor's Office, Burnley.
BRYANS, J. G.	Resident Engineer's Office, Calle Piedad, 228, Buenos Aires.
BRYNING, W. G.	Derby Lane, Old Swan, Liverpool.
COOK, J.	Borough Surveyor's Office, Bury.
COOPER, C. H., A.M.I.C.E. ..	Surveyor's Office, Wimbledon.
CROW, A.	35, Queen Victoria Street, E.C.
FENTON, W. C.	Borough Surveyor's Office, Sheffield.
FRANKS, T. W.	Town Hall, West Bromwich.
GLASS, S. N.	Town Hall, Hackney, E.
GREATOREX, A. D.	Surveyor's Office, Town Hall, Manchester.
HOUGHTON, J.	King's Heath, Birmingham.
JAMESON, M. W.	Local Board, South Hornsey, N.
LYNAM, G. T.	Borough Surveyor's Office, Burnley.
MELLOR, T. E. W...	Town Surveyor's Office, Tunbridge Wells.
NICKOLS, F. J.	Borough Surveyor's Office, Leeds.
PARKER, W.	Borough Surveyor's Office, Hereford.
PICKERING, J. S.	East Warwickshire Waterworks, Nuneaton.
PRITCHARD, T.	Town Surveyor's Office, Richmond, Surrey.
RICH, E. W.	Alderwich House, Hounslow.
SAUNDERS, J.	Borough Surveyor's Office, Newark.
SMITH-SAVILLE, R. W... ..	Borough Surveyor's Office, Accrington.
WARD, F. D.	84, Allington Street, St. Michael's, Liverpool.
YOUNG, W..	Town Hall, Salford.

TOWNS AND DISTRICTS REPRESENTED BY MEMBERS OF THE ASSOCIATION.

Abergavenny	Jon. Haigh.
Abingdon	G. Winship.
Abram	Geo. Heaton.
Accrington	W. J. Newton.
"	E. Knowles.
Aldershot	W. L. Coulson.
Alnwick	G. Wilson.
Alton	J. Barlow.
Altrincham	J. Stokoe.
Alverstoke	W. H. Fry.
Amble	J. McLaren.
Arbroath	J. D. Watson.
Ashby-de-la-Zouche (R.S.A.)	J. W. Metcalf.
Ashford	J. Willson.
Ashton-under-Lyne	J. T. Earnshaw.
Aspull	Geo. Heaton.
Aston Manor	W. A. Davies.
Audenshaw	J. H. Burton.
Aylesbury	G. Cannon.
Bacup	J. Wilson.
Barking	C. J. Dawson.
Barrow-in-Furness	W. H. Fox.
Barton-upon-Irwell (Rural)	C. C. Hooley.
Basford Union (R.S.A.)	J. Parker.
Batley	J. W. Horsfield.
Battersea	J. T. Pilditch.
Beckenham	G. B. Carlton.
Bedford	J. Lund.
Belgrave	R. J. Stephens.
Benwell	T. Dawson.
Berwick-on-Tweed	D. M. MacGregor.
Beverley	J. Beaumont.
Bingley	R. Armistead.
Birkenhead	T. C. Thorburn.
Birmingham	W. S. Till.
"	E. Pritchard.
Bishop's Stortford	R. S. Scott.
Bishop's Stortford (R.S.A.)	E. T. Watts.
Blackburn	J. B. McCallum.
Blackpool	J. Wolstenholme.
Blaina	G. Stevens.
Blaydon-on-Tyne	M. Hawdon.
Bolton	W. H. Brockbank.
"	J. Proctor.
Bootle-cum-Linacre	W. N. Blair.
Boston	W. H. Wheeler.
Bournemouth	F. W. Lacey.
Bowdon	J. Newton.
Bradford	J. H. Cox.
Bradford-on-Avon	J. Standfield Brun.
Bray, Ireland	F. C. Comber
Brecknock	R. Davies.
Brentford	J. H. Strachan.

Bridgewater	G. B. Laffan.
Bridlington	R. B. Brown.
"	S. Dyer.
Brighton	G. R. Andrews.
"	P. C. Lockwood.
Brisbane, Queensland	T. Kirk.
Bristol	F. Ashmead.
Bromley	H. S. Cregeen.
Burnley	F. S. Button.
Burslem	J. E. Worth.
Burton-upon-Trent	E. Clavey.
Bury	J. Cartwright.
"	J. Farrar.
Buxton	J. Hague.
Carlisle	H. U. McKie.
Carshalton	T. L. Howard.
Cheadle	E. Sykes.
Chelsea	G. R. Strachan.
Cheltenham	G. W. Sadler.
Cheshunt	T. Bennett.
Chester	I. M. Jones.
Chesterton	D. Bland.
Chichester	H. W. Stringfellow.
Chiswick	A. Ramsden.
Clacton-on-Sea	G. H. Sasse.
Clapham, S.W.	A. Southam.
Clevedon, Somerset	H. Taylor.
Cockermouth	R. S. Marsh.
Colchester	H. Goodyear.
Colne	J. Mallinson.
Compton Gifford	J. C. Inglis.
Coventry	E. J. Purnell.
Crewe	G. Eaton-Shore.
Crompton	J. Mawson.
Croydon	T. Walker.
" (Rural)	R. M. Chart.
Dalton-in-Furness	William Wilson.
Darlaston	T. W. Debney.
Dewsbury	H. C. Marks.
Doncaster	W. H. R. Crabtree.
Dorking	G. S. Mathews.
Dorking (R.S.A.)	W. Rapley, jun.
Dover	W. Thomas.
Dublin	C. Harty.
Dudley	J. Gammage.
Dukinfield	W. Spinks.
Dunoon	Jas. Collie.
Ealing	C. Jones.
Eastbourne	C. Tomes.
East Ham	W. H. Savage.
Edinburgh	J. Cooper.
Edmonton	G. E. Eachus.
Ely	W. McKelvie.
Epsom	J. R. Harding.
Eston District	T. W. Stainthorpe.
Failsworth	C. J. Lomax.
Fenton	S. A. Goodall.
Finchley	F. Smythe.
Fleetwood	M. S. Gaulter.

Frome	P. Edinger.
Fulham	J. P. Norrington.
Gateshead-on-Tyne	J. Bower.
Gloucester	R. Read.
Gloucester (County)	R. Phillips.
Goole, Yorkshire	E. C. B. Tudor.
Gorton	T. Mayor.
Grantham, Lincolnshire	S. G. Gamble.
Great Crosby	W. Hall.
Great Grimsby	J. Buchan.
" "	J. Maughan.
Great Yarmouth	J. W. Cockrill.
Halifax	E. R. S. Escott.
Hampstead	C. H. Lowe.
Hanley	J. Lobley.
Harborne	R. Dixon.
Harrow	E. R. Capon.
Hartlepool	H. C. Crummack.
Harwich	H. Ditcham.
Haverhill	J. Kemp.
Headington (Rural)	L. Turner.
Heckmondwike	T. Gledhill.
Hendon	S. S. Grimley.
Hereford	J. Parker.
Hertford	W. H. Wilds.
Heston and Isleworth	W. B. Bromley.
Hexham	R. Grieves.
Heywood	J. Diggle.
Hinckley	W. W. Cooper.
Hornsea	P. Gaskell.
Hornsey	T. De C. Meade.
Hove	H. H. Scott.
Hull	A. E. White.
Huntingdon	R. Hutchinson.
Hurst Brook	J. Heys.
Hyde	J. Mitchell.
Ipswich	E. Buckham.
Islington, Parish of	C. Higgins.
Jarrow	J. Petree.
Kearsley	T. Nuttall.
Keighley	W. H. Hopkinson.
Kensington	W. Weaver.
Kidderminster	A. Comber.
King's Lynn	E. J. Silcock.
King's Norton (Rural)	R. Godfrey.
Kirkleatham	J. Howcroft.
Lancaster	A. Creer.
Leamington Spa	W. De Normanville.
Leeds	T. Hewson.
Leek	J. Myatt.
Leicester	E. G. Mawbey.
Lewes	A. Holt.
Leyton, E.	W. Dawson.
Lichfield	C. J. Corrie.
Lincoln	R. A. MacBrair.
Littleborough	F. H. Shuttleworth.
Liverpool	C. Dunscombe.
"	G. F. Deacon.
"	G. Biddle.

LLANDUDNO	T. T. Marks.
LOFTUS IN CLEVELAND	C. A. Copland.
LONDON (County)	J. Gordon.
LONDONDERRY, IRELAND	W. J. Robinson.
LONGTON	J. W. Wardle.
LOUGHBOROUGH	Geo. Hodson.
LOUTH	T. W. Wallis.
LOWESTOFT	G. H. Hamby.
LUTON, BEDFORDSHIRE	W. H. Leete.
MACCLESFIELD	J. Wright.
MAIDSTONE	F. J. C. May.
„ (Rural)	E. P. Hooley.
MALDON (Rural)	A. Stewart.
MALTON	J. L. Webster.
MANCHESTER	J. Newman.
„	S. C. Trapp.
MANSFIELD	R. F. Vallance.
MARGAM	W. Thomas.
MARKET HARBORO	H. G. Coales.
MELTON MOWBRAY	E. Jeeves.
MEXBOROUGH	T. Humphries.
MIDDLESBROUGH	E. D. Latham.
MIDDLETON, LANCASHIRE	W. Welburn.
MILLOM	H. Waye.
MILVERTON	G. F. Smith.
MIRFIELD	F. H. Hare.
MONMOUTHSHIRE (County)	W. Tanner.
MONTREAL, CANADA	P. St. George.
MORPETH	T. W. Middlemiss.
NEATH	D. M. Jenkins.
„ (R.S.A.)	W. E. C. Thomas.
NELSON-IN-MARSDEN	W. Dent.
NESTON	J. Morris.
NEWARK	Geo. Sheppard.
NEW BARNET	G. W. Brumell.
NEW MALDEN	T. L. Heward.
NEWCASTLE-ON-TYNE	W. G. Laws.
„	J. P. Spencer.
NEWCASTLE-UNDER-LYME	J. Pattison, jun.
NEWTON HEATH	J. P. Wilkinson.
NEWTON-IN-MAKERFIELD	R. Brierley.
NORDEN	Geo. Land.
NORTH BIERLEY	P. Ross.
NORWICH	P. P. Marshall.
NOTTINGHAM	A. Brown.
OKEHAMPTON	H. Geen.
OLDBURY	H. Richardson.
ORRELL	G. Heaton.
OSWESTRY	H. T. Wakelam.
OUNDLE	J. M. Siddons.
OVER DARWEN	W. Stubbs.
OXFORD	W. H. White.
PADDINGTON	Geo. Weston.
PADIHAM	J. Gregson.
PAIGNTON	W. J. Wyatt.
PEMBERTON	Geo. Heaton.
PETERBOROUGH	J. W. Walshaw.
PINNER	C. A. Woodbridge.
PLUMSTEAD	W. G. Forder.

Plymouth	G. D. Bellamy.
„	R. Hodge.
Poole	J. Elford.
Pontypool	D. H. W. Powell.
Portsmouth	H. P. Boulnois.
Prescot	W. Goldsworth.
Putney	J. C. Radford.
Ramsbottom	T. Nuttall.
Ramsgate	W. A. M. Valon.
Rawtenstall	J. E. Swindlehurst.
Reading	A. W. Parry.
Redditch	S. E. Thorrold.
Rhyl	Robt. Hughes.
Richmond	W. Brooke.
Rochdale	S. S. Platt.
Rochester	W. Banks.
Rotherham	G. Jennings.
Royton	W. Diggle.
Rugby	W. Stewart.
Ryde	F. Newman.
Sale	A. G. McBeath.
Saltburn-by-the-Sea	R. A. Worswich.
Selby	T. Mallinson.
Sevenoaks	J. Mann.
Shanghai, China	C. Mayne.
Shaw	J. Mawson.
Sheffield	C. F. Wike.
„	R. Davidson.
Sherborne	T. Farrall.
Shifnal	W. F. T. Molineux.
Shirley and Freemantle	H. J. Weston.
Skelton in Cleveland	J. W. Witts.
Sleaford	Jesse Clare.
Smethwick	J. C. Stuart.
Southampton	W. B. G. Bennett.
„	J. Lemon.
Southend-on-Sea	P. Dodd.
Southgate	C. G. Lawson.
Southport	W. Crabtree.
South Hornsey	Ed. Fry.
South Shields	M. Hall.
Stafford	W. Blackshaw.
Stamford	Jas. Richardson.
Stockport	A. M. Fowler.
Stockton	K. P. Campbell.
Stoke-on-Trent	W. Bowen.
Stourbridge	W. Fiddian.
Strand	A. Ventris.
Stratford-on-Avon	T. T. Allen.
Streatham	Jas. Barber.
Stretford	H. Royle.
Stroud	J. P. Lofthouse.
St. George, Bristol (R.S.A.)	Wm. Cloutman.
St. George the Martyr, Southwark	A. M. Hiscocks.
St. Giles	G. Wallace.
St. Luke, Middlesex	M. C. Meaby.
St. Mary, Islington	J. P. Barber.
St. Saviour, Southwark	G. R. Norrish.
St. Thomas, near Exeter	S. Churchward.

Sunderland	R. S. Rounthwaite.
Sutton, Surrey	E. W. Crickmay.
Swansea (Rural)	J. Thomas.
Swinton, Yorkshire	J. C. Haller.
Sydney, N.S.W.	R. W. Richards.
Tamworth (R.S.A.)	H. J. Clarson.
Tewkesbury, Gloucestershire ..	W. H. Gray.
Tiverton, Devon	Wm. Rowe.
Todmorden	A. Greenwood.
Tooting	Jas. Barber.
Torquay	Joseph Hall.
Tottenham	J. E. Worth.
Toxteth Park	J. Price.
Tunstall	A. R. Wood.
Turton	Jas. Parkinson.
Ulverston	Hy. Whitlow.
Ventnor	J. G. Livesay.
Wakefield	R. Porter.
Walsall	A. Hardwicke.
Walsoken	J. Kerridge.
Walton-on-the-Hill	S. Middlebrook.
Wanstead	J. T. Bressey.
Warrington	T. Longdin.
Waterloo, Liverpool	R. Thompson.
Watford	C. C. Lovejoy.
Wavertree	I. Dixon.
Wellingborough	E. Sharman.
West Bromwich, Staffordshire ..	J. T. Eayrs.
West Ham, London	L. Angell.
Westhampnette (R.S.A.)	J. T. Hawkins.
West Hartlepool	J. W. Brown.
Westminster	G. R. W. Wheeler
Weston-super-Mare	A. E. Collins.
Weymouth and Melcombe Regis ..	W. B. Morgan.
Whitehaven	J. S. Brodie.
"	R. Pickering.
Widnes	T. Higginson.
Willesden	O. C. Robson.
Wimbledon	W. Santo Crimp.
Withington	A. H. Mountain.
Wolverhampton	R. E. W. Berrington.
Woodford	J. D. Hooper.
Wood Green	C. L. Walker.
Worksop	J. Allsopp.
Worthing	W. Horne.
Wrexham	J. W. M. Smith.
"	A. S. Jones.
" (Rural)	A. C. Bauch.
Wuerdle and Wardle	G. H. Wild.
York (Rural)	W. G. Penty.

PARLIAMENTARY COMMITTEE.

E. B. Ellice-Clark, *Chairman.*

Lewis Angell (West Ham).
Chas. Jones (Ealing).
T. De C. Meade (Hornsey).
A. Parry (Reading).
O. C. Robson (Willesden).
W. H. White (Oxford).

RULES OF THE ASSOCIATION.

I.—That the Society be named the "Association of Municipal and Sanitary Engineers and Surveyors."

II.—That the objects of the Association be—

a. The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.

b. The promotion of the professional interests of the Members.

c. The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, or under the Metropolis Local Management Acts. Each Candidate for Membership shall be proposed by at least two Members, who from personal knowledge of such Candidate shall certify that he possesses the necessary qualification. Candidates residing outside England and Wales not known by two Members of this Association may be proposed by three Corporate Members of the Institution of Civil Engineers. Members who cease to hold their appointments are eligible for re-election by the Council, but will be disqualified from holding any office. Civil Engineers and Surveyors holding other chief permanent appointments under any Public Authority within the United Kingdom, or in the Colonies or Foreign Countries, shall be eligible for election as Members, subject to the approval of the Council. The Council shall also have power to elect such Honorary Members as they may see fit.

IV.—That the affairs of the Association be governed by a Council, consisting of a President, Three ViceP-residents, Twelve Members, and an Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, six for Vice-Presidents, one for Honorary Secretary, and fifteen for Ordinary Members of Council. In addition to these each Member of the Association shall be at liberty to nominate one Member for the Council, but in the event of the last-named Nominations exceeding fifteen, the Council shall reduce them to that number, so as to leave thirty names in all from which to elect the required number of Ordinary Members of Council. Members' Nominations must be

in the hands of the Secretary on or before the 20th of April in each year. And in case the Members' Nominations should not reach fifteen, the Council shall have the power to make up the total number of Nominations to thirty. Such list of thirty Nominations shall be printed and sent to each Member of the Association not less than fourteen days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations, or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days from the date of issue. Such ballot papers shall be examined in London by the President, Secretaries, and two Scrutineers appointed at the previous Annual Meeting, or by any two of the aforesaid Members. Any Member canvassing for votes for the office of Member of Council shall be considered ineligible for election.

VI.—That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a District Secretary, who will keep records of local proceedings, and communicate with the Council. All District Secretaries shall vacate their office at the Annual Meeting, and Members shall then be appointed to act as Local Secretaries until a District Meeting can be arranged, at which Meeting a District Secretary shall be appointed.

VII.—That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII.—That each Member pay an entrance-fee of One Guinea, and a subscription of One Guinea per annum.

IX.—That no new Rule or alteration of any existing Rule be made unless Notice of Motion for such purpose, and the proposed Resolution thereon, be sent to the Secretary by the 31st March, and such Notice of Motion and Resolution shall be printed in the Agenda for the ensuing Annual Meeting.

X.—That Candidates successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as Members of the Association, shall constitute a class of Graduates, on payment of an annual subscription of One Guinea; and as such shall be entitled to attend the General and District Meetings and to take part in the proceedings thereof, and be entitled to a copy of the Minutes of the Proceedings, but shall not take part in the election of the Council. Graduates shall be transferred to the class of Member when qualified according to Rule III. A Graduate shall not be required to pay an entrance fee either on his becoming a Graduate or on his transfer as a Member.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

SIXTEENTH ANNUAL MEETING.

Portsmouth, *July 4th, 5th, and 6th,* 1889.

GENERAL BUSINESS.

The Members assembled in the Council Chamber, Guildhall, Portsmouth, where the Mayor (G. Ellis, Esq.) warmly welcomed the Association to Portsmouth. Mr. Ellice-Clark, President, took the chair, and the Minutes of the Annual Meeting held in London in July 1888 were read, confirmed, and signed.

The Secretary then read the Council's Annual Report for the year ending April 30th, 1889.

ANNUAL REPORT.

The Council have much pleasure in meeting the Members, and in presenting the Annual Report of the proceedings of the past year. They have also much satisfaction in being able to state that the progress of the Association is well maintained.

Since the last General Meeting in London on the 12th, 13th, and 14th July, 1888, there have been held five District Meetings—at Vyrnwy, on the 29th September; at Sunderland, on the 23rd of March, 1889; at Southampton, on the 4th of May; at Salford, on the 17th of May; and at Hull, on the 22nd of June. The meeting at Vyrnwy and the meeting at Salford—the former the works of the Liverpool water supply, and the latter the works of

the Manchester Ship Canal—afforded opportunities of inspecting two of the greatest engineering undertakings of the present day. Although the number of the District Meetings has this year scarcely come up to the average of past years, they have in their instructive value and in their interest been quite equal to any that have preceded them, and the Council again desire to place on record the kind assistance accorded to the Association by the various Municipal and other authorities, whose courteous receptions have done so much towards the success of the meetings.

During the financial year, ending April 30th, thirty-one new Members, consisting of twenty-one Ordinary Members, and ten Graduates have joined the Association, three names have been written off, and the Council regret to report the deaths of Mr. Batten of Birmingham, Mr. Cruse of Warminster, Mr. Harpur of Merthyr Tydvil, Mr. Miles of Blaby, and Mr. Rumble of New Barnet.

The number on the roll of the Association at the close of the year was—13 Honorary Members, 333 Ordinary Members, and 25 Graduates, making a total of 371, as against 349 at the end of last year.

The audited Balance Sheet, which accompanies this Report, shows a balance in hand on April 30th of 320*l.* 11*s.* 5*d.*, as against a sum of 369*l.* 1*s.* 7*d.* on April 30th, 1888. The extra expenditure on the volume of 'Proceedings,' and the amount charged to "office furniture," accounts for this somewhat diminished balance. Taken, however, with the statement of assets and liabilities, the financial position of the Association is satisfactory.

The Ballot lists having been duly issued, the Scrutineers report the following gentlemen elected for the Council:—

President.—H. P. Boulnois.

Vice-Presidents.—C. Dunscombe, T. Hewson, and T. De C. Meade.

Ordinary Members of Council.—W. B. G. Bennett, A. Brown, J. Cartwright, J. H. Cox, W. S. Crimp, J. T. Eayrs, E. R. S. Escott, A. M. Fowler, J. B. McCallum, H. U. McKie, A. W. Parry, and T. Walker.

Honorary Treasurer.—L. Angell.

Honorary Secretary.—C. Jones.

The Council have found it necessary to secure additional accommodation for the convenience of their meetings, and have accordingly entered into arrangements with the Secretary for the

use of a room, which they furnish, and towards the rent of which they agree to pay 20*l.* a year.

The Council have had under their consideration the question of premiums for papers, and have resolved to offer annually two premiums of 10*l.* and 5*l.* respectively, for the two best papers read after the Annual Meeting of July, 1888, and the Council have nominated a Committee, consisting of the Past Presidents of the Association, to award the premiums, and reserve to themselves the right of withholding the premiums should they consider the papers are below the required standard of merit.

The Sewer Ventilation Committee report that they have collected much evidence bearing on the subject of their investigations, and the Council had hoped to have reported the conclusion of their labours; unfortunately, however, owing to the illness of one of the principal members of the Committee, the embodiment of their work is unavoidably delayed.

Since the last Report two examinations have been carried out, the first of which was held on the 26th and 27th October, 1888. At this examination ten candidates presented themselves, of whom the following satisfied the examiners, and were granted certificates of competency:—R. R. Brown (Bridlington Quay), W. G. Bryning (Liverpool), W. C. Field (Eastbourne), I. T. Hawkins (Chichester), J. S. Millington (Wavertree), and J. B. Wilson (Cockermouth). The examiners were Messrs. L. Angell, H. P. Boulnois, C. Dunscombe, and C. Jones. The second examination was carried out on the 29th and 30th March, when eighteen candidates presented themselves, and of these the following satisfied the examiners and were granted their certificates:—J. H. Blizard (Southampton), J. W. Bradley (Burnley), G. F. Carter (Leeds), W. B. Dixon (Wolverhampton), H. Nettleton (Leeds), W. Stringfellow (Southampton), W. J. Taylor (Southampton), and G. B. Tomes (Eastbourne). The examiners were Messrs. L. Angell, C. Dunscombe, H. P. Boulnois, and C. Jones. Both of these examinations were held at the Institution of Civil Engineers, the use of which was kindly granted by the Council of that body.

The Committee of the Council having very carefully considered the question of Registering the Association under the Companies Act, and of the advantages that such incorporation would afford especially in the matter of examinations, report strongly in favour of such a step being taken. The Council fully approve this report, and accordingly a resolution is placed on the agenda paper for

your consideration, having for its object the necessary permission to carry the Council's recommendation into effect.

The Report was unanimously adopted. It having been moved and seconded, it was agreed that the various District Secretaries continue in office till the next Meeting in their respective districts.

Messrs. Brooke, Eachus, Lowe, and Radford, were appointed Scrutineers for the ensuing year.

Messrs. R. Godfrey and S. Gamble were appointed Auditors for the ensuing year.

Mr. J. Gordon proposed and Mr. White seconded a hearty vote of thanks to the retiring President for his valuable services to the Association during the past year.

The resolution having been unanimously adopted, Mr. Ellice-Clark returned thanks and introduced the President-Elect, Mr. H. Percy Boulnois, who then took the chair.

Mr. Lewis Angell then moved the following resolution:—

"That the Association be registered under the Companies Act, and that a Committee of five Members be appointed, with full powers to carry the aforesaid resolution into effect."

This was seconded by Mr. Gamble, and carried unanimously.

The Committee to consist of the following five gentlemen:—

W. Santo Crimp (Wimbledon).
G. E. Eachus (Edmonton).
T. De C. Meade (Hornsey).
O. C. Robson (Willesden).
T. Walker (Croydon).

With the President, Hon. Treasurer, and Hon. Secretary as ex-officio members.

The President then read his inaugural address.*

CHAS. JONES, *Hon. Sec.*
THOMAS COLE, *Secretary.*

* This Address and the papers read at the meeting will be found at the end of the volume.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING APRIL 30TH, 1889. Cr.

RECEIPTS.	£	s.	d.
To Balance at Bank (May 1st, 1888)	369	1	7
„ Entrance Fees	19	19	0
„ Subscriptions	281	8	0
„ Subscriptions paid in advance	8	8	0
„ Arrears	46	4	0
„ Publishers, Sale of Proceedings	28	2	8
„ Examination Fees	84	10	6
„ Balance of Petty Cash due to Secretary	5	18	3
	£843	12	0

EXPENDITURE.	£	s.	d.
By Report Annual Meeting, London	10	10	0
„ „ District Meeting, Carlisle	2	10	0
„ „ „ „ Lincoln	4	4	0
„ „ „ „ Maidstone	2	2	0
„ „ „ „ Leamington	3	3	0
„ „ „ „ York	3	3	0
„ „ „ „ Sunderland	2	2	0
„ Messrs. Clowes (Printing vol. xiv., &c.)	187	12	6
„ „ Irvine (Printing, addressing, and posting circulars) 1st account	37	13	7
„ „ Irvine (ditto, ditto) 2nd account	15	0	7
„ Fees to Superintendent Examiner, Examiners and sundry expenses, October and April Examinations	48	6	0
„ Expenses Annual Meeting	10	0	0
„ Messrs. Waterlow	0	17	0
„ Office Furniture	34	18	6
„ Solicitors—Pritchard and Co.	5	5	0
Messrs. Hallowes	2	13	8
„ Messrs. Cook and Hammond	1	0	0
„ Secretary's Salary	100	0	0
„ Rent of Office	15	0	0
„ Petty Cash.—Postages	8	15	0
Stationery and Sundries	28	4	3
„ Bank Charges	0	0	6
„ Balance at Bank (May 1st, 1889)	320	11	5
	£843	12	0

STATEMENT OF ASSETS AND LIABILITIES, APRIL 30TH, 1889.

LIABILITIES.	£	s.	d.
To Estimated Liability on vol. xv.	30	0	0
„ Sundry Printing	30	0	0
„ Secretary, Balance of Petty Cash	5	18	3
„ Outstanding Accounts	0	0	0
„ Examiners' Expenses Estimated	25	0	0
„ Balance	380	9	11
	£471	8	2

ASSETS.		£	s.	d.
By Balance at Bank		320	11	5
„ Subscriptions in Arrear	£82 19 0			
„ „ less 50 per cent. bad	41 9 6—	41	9	6
„ Proceedings in Stock	£218 14 6			
„ „ less 50 per cent.	109 7 3—	109	7	3
		£471	8	2

Examined and found correct, ROBT. GODFREY, GEO. R. STRACHAN, } *Auditors.*

June 22nd, 1889.

LEWIS ANGELL, *Treasurer.* CHAS. JONES, *Hon. Secretary.*
THOMAS COLE, *Secretary.*

DISTRICT MEETING AT VYRNWY.

September 29th, 1888.

THE LIVERPOOL WATERWORKS.

This was the second visit of the Association to these works—the first occasion being during the Presidency of Mr. C. Jones, October 18, 1882.—and an account of the visit and of the works will be found in the IXth. volume, of the 'Proceedings' of the Association.

These works were commenced in 1881, so that the members, on the occasion of the first visit, had an excellent opportunity of inspecting the work in its early stages, more particularly the foundation in connection with the masonry dam, whilst the second visit afforded an opportunity for an inspection of the works in a more completed state. Few people can have any knowledge of the impediments that have cropped up at every step in the progress of the works.

The river Vyrnwy is one of the most important sources of the Severn, and it therefore devolved upon the Navigation Commissioners and other bodies interested in the waters of the latter river to secure such a continuous supply from Lake Vyrnwy as would compensate the river for the loss of a portion of the Vyrnwy drainage area. They have not only done this, but their arrangement is of such a nature that throughout the year they will receive three or four times as much water as the dry-weather flow of the Vyrnwy, while in the summer the supply will be still further increased. The Corporation are compelled by their Act of Parliament to provide compensation water to the extent of 10,000,000 gallons daily, with an additional 40,000,000 gallons during four days in each of the eight dry months of the year—that is to say, from March to October, inclusive. In consequence of this the expense of the dam was considerably increased. This is but one instance of the contingencies which have arisen since the commencement of operations, and which have involved an extension of the

original estimates. The minimum flow of the stream in June 1884, was about 2,000,000 gallons per day. The maximum flow has not reached 1,800,000,000 since the records were commenced in 1878. In the valley stands the ancient village of Llanwddyn, which is soon to disappear. Some of the houses have already been demolished, others are in process of demolition, and the remainder will not be spared long. The village formerly consisted of about 30 houses, a parish church, two chapels, an hotel, and two public-houses. The old road, which has existed for centuries, and was the highway from Llanfyllin to Bala, passes through the centre of the valley, and as it will be submerged by the impounded water, it has been necessary for the Corporation to construct an entirely new road. A road varying in elevation from 10 to 30 feet above the high-water level, and nearly 12 miles in length, has been made around what will, in the near future, be a vast lake. On the side of a hill some distance from the village a new church and a vicarage have been erected, and the bodies from the old churchyard have been removed to and solemnly interred in the churchyard attached to the new edifice. Dwelling-houses are to be provided for the villagers. The Corporation are the owners of 13,000 acres of the area surrounding the site of the lake, and on plots of this land now exist the temporary dwellings of the engineering staff and of the employés engaged in the various works.

The Vyrnwy rises to the east of the Berwyn range of mountains, and flows through the valley, which is a tract of alluvial land about five miles in length, and varying in width from a quarter to half a mile. The average rainfall is about 70 inches. Of the twenty rain gauges which have been in operation upon the Vyrnwy drainage area for many years, one to the east has recorded 49·73 inches of rain in a year, while another to the west has recorded 118·51 inches in a similar period, or more than three and a half times as much as the average rainfall in Liverpool. This should dispel the doubt, if any exist, as to a possible insufficiency of supply. The entire watersheds will cover an area of 23,000 acres; the water from 18,000 acres will flow into the Vyrnwy valley direct, the remainder being the flow of the streams, Afon Conwy and Marchnant, which will be connected with the valley by means of tunnels before the scheme is completed. The lake itself will be nearly 5 miles long, and will have an area of 1,115 acres and contain 12,000,000,000 gallons. The high-water level will be 825 feet above the level of the sea. The first instalment of water to Liverpool will be

something like 13,000,000 gallons per day, but when the works are finished in their entirety the daily supply is expected to come up to 40,000,000 gallons, a quantity very far in excess of the present requirements of the district supplied.

For the storage of water 84 feet above the bed of the river it was necessary to have a dam 144 feet above the lowest rock foundation. The Vyrnwy dam has a sound foundation on rock commonly called clay-slate. It is 1173 feet in length, and the contents of the wall are about 260,000 cubic yards. The stone of which the dam is built stands an average pressure of over 800 tons per square foot, and the mortar stands, after two years, 275 tons per square foot; whilst the concrete stands between 200 and 300 tons per square foot before cracking or showing any signs of failure. It has been stated on good authority that the greatest weight per square foot on any part of the masonry is only 3 to 4½ per cent. of the actual crushing stress of the cement concrete and 1 to 1¼ per cent. of the crushing stress of the stone. The Vyrnwy dam has been constructed under conditions very similar to those which guided the French engineers in the work of the Furens reservoir and of Gen. Fife, R.E., in the construction of the Karakvasla dam near Poonah. The dam is constructed of stones from 1 to 10 tons weight dressed to a flat surface on the underside. Each stone is bedded in strong cement mortar and the interstices between them are rammed with smaller stones and cement mortar. In portions of the dam far from the water face cement concrete is similarly used. The rock from which the stones are obtained weighs 2·06 tons per cubic yard. The dam contains about 250,000 cubic yards of material, and weighs about 500,000 tons. Samples having been taken from the dam for testing, the weakest was found to bear 150 tons to square foot. The maximum pressure on the wall is about 8 tons per square foot. The water face joints in the stonework are at first unfilled to a depth of six inches, and are subsequently filled in with cement mortar and caulked. At the top of the dam there is a viaduct, with a series of well-formed arches of 24 feet openings between the valve towers, through which the flood water will flow in a cascade from the reservoir to the basin below. On the top of the dam, and over the arches, three cranes are now employed hoisting stones for levelling the wall prior to the formation of the road from one side of the valley to the other. This new roadway will be 22 feet wide, with a small footway on each side, and walls designed in such a way as to afford the best

protection to pedestrians whilst improving the appearance of the structure. In the dam there are two apertures 15 feet in diameter, through one of which the river was flowing, but both are to be immediately built up with bricks and cement. In the central portion of each there will be laid a pipe governed by two valves. By means of a second pipe in the southern tunnel the water will be conducted to the measuring house where the compensation water will be regulated. The Hirnant tunnel is 7 feet in diameter, 2¼ miles in length, and forms part of the aqueduct. From this tunnel a culvert extends to the Vyrnwy tower, which is now a conspicuous object in the valley. From an engineering point of view, this is one of the most interesting features of the works. It serves two principal objects: the first being to draw off the water at any desired level from the lake, and the second to strain from it the floating particles which so greatly increase the cost of filter bed maintenance. The strainers are of copper, 120 meshes to the lineal inch, are 9 feet in diameter, and 25 feet high. The principles of construction and the nature of the machinery to be used were fully explained. This tower, which is situated at a considerable distance from the disturbing influence of any tributary stream, is approached by a masonry viaduct.

At Oswestry, a distance of 17 miles 634 yards at the mouth of the Llanforda tunnel, the water is received into a storage reservoir covering 17 acres and containing 50,000,000 gallons. From this reservoir the water is delivered into filter beds three in number (in course of construction), each having an area of 8000 square yards; the water is filtered through sand and gravel, and then sent on to Liverpool. There are four balancing reservoirs on the way:—
1. Parc Uchaf; 2. Oat Hill near Malpas; 3. Cote brook;
4. Norton Tower.

There are two important river crossings, the Weaver navigation, and the Mersey at Runcorn—this latter is, under a decision of the Board of Trade, to be in tunnel; but at the Weaver the aqueduct will pass beneath the bed of the stream in steel tubes.

The scheme was projected by the reports made to the Corporation of Liverpool in 1887 and 1878 by Mr. Deacon, who, in 1879, prepared the Parliamentary plans. In the autumn of that year Mr. Hawksley became associated with Mr. Deacon in the undertaking, but resigned in 1885, and the works are now drawing towards completion under Mr. Deacon.

DISTRICT MEETING AT SUNDERLAND.

March 23rd, 1889.

Held in the Committee Room in the Municipal Buildings, Sunderland.

E. B. ELLICE-CLARK, *President, in the Chair.*

The following Papers were read and discussed:—

ON THE AIR PRESSURE IN SEWERS.

BY JOHN PETREE, BOROUGH SURVEYOR, JARROW.

IT is not my intention to advocate the principle that the air from sewers is in no way innocuous; yet I am not at all disposed to consider it of such a dangerous nature as is generally supposed.

A very able paper by Mr. J. S. Haldane on the "Air of Buildings and Sewers," was read during the Congress of The Sanitary Institute of Great Britain, at Bolton, in September, 1887, and published in the 'Sanitary Record' of the following month.

That writer, after careful investigation of the subject, states* that "sewer air has commonly been supposed to be 'loaded' with micro-organisms, whereas, in reality, it turns out to be some of the freest air from micro-organisms that can be found."

Further on, "What is the supposed evidence for the causation of typhoid fever and other diseases by the inhalation of sewer air? We may dismiss at once, as absolutely worthless, collections of cases in which something has been found wrong with the drains in a house where a case of typhoid fever has occurred, or where the patient has been found to have sniffed at a sewer grating or ventilating pipe shortly before his illness."

* 'Sanitary Record,' page 158.

Almost every person who has been in any way connected with sanitary matters and house drainage, will at times have heard it said that the gases generated in sewers will pass through traps, sealed with water, and in this way enter the dwellings, not only of the very poor, but also (and more frequently) the better class of houses, occupied by those who have ample means to adopt the most costly appliances to secure protection from the insidious enemy.

Manufacturers have endeavoured to meet the demand for traps with such a depth of seal that the effect produced may be compared to using the strength of a strong man against a force which a child might resist.

Recently I had occasion to cause the depth of seal in a syphon trap to be measured previous to fixing. This was found to be 6 inches, whilst the depth of seal to an ordinary yard sink was found to be 6¼ inches.

When we consider the power required to carry floating matter to a depth of 6¼ inches before it can be discharged into the sewer, we are struck with the thought that such a contrivance is well adapted to retain filth, so that decomposition may be accomplished near to the dwelling, instead of immediately passing it into the sewer to be carried away at once.

Probably few towns in England are to be found where sewers are not ventilated, either by (1) openings at the street level, (2) shafts carried up the gables of houses, or (3) the more effectual means of furnaces and tall chimneys in cases where the cost is not too great to admit of that mode being adopted.

Where sewers are thus ventilated, we may safely estimate the pressure of sewer air upon household stench traps, when the course for sewerage is not obstructed by foreign matter, by atmospheric weight.

There cannot be a greater upward pressure from the sewer at two given points than the difference of weight between the atmospheres at those points, in other words between the lower and higher levels.

Further, where openings are made all along the route, each of those openings will in many cases act as upcast and downcast at the same time; the upward current at one side, and the down current at the opposite side of the shaft, the down current moving forward and along the sewer, displacing the air and discharging it at the next higher opening, and onwards until the end of the sewer system is reached.

We will now endeavour to ascertain what amount of force might reasonably be found acting upon the water in the trap, separating the sewer air from that within the dwelling.

The gases contained in sewer air must (if it is intended to rise at all) necessarily be of less weight than the air in which it floats. Gases of greater density will undoubtedly fall, and, when in contact with flowing sewage, will be carried to the outfall.

Water being say 800 times heavier than atmospheric air, while the gases must be of still less weight, the air within the sewer when of higher temperature will be of less density, otherwise the sewer gas would never be in contact with the water contained in a trap. Hence the force exerted must be greater than the weight of water to cause a light elastic fluid to penetrate through a non-elastic substance of greater density.

Take, for instance, a dwelling house 30 ft. in height; suppose a cubic foot of air to be taken from the lowest room, in which the temperature is found to be 72°, while the temperature of the outside air is 22°, or 10° below freezing point.

The difference in weight of air at 22° and at 72°, multiplied by 30 feet (the height of the column inside the house), will represent the amount of force, or pressure, required to drive sewer air past or through the seal of water contained in the trap, before it can enter the house.

From "Box's Practical Treatise on Heat," table 19—the weight of dry air at various temperatures under a constant atmospheric pressure of 29·92 inches of mercury in the barometer—I obtain data for the following:—

	in lbs.
Weight of a cubic foot of air at 22° temperature	·0824
,, ,, ,, 72° ,, ...	·0747
Difference	·0077
Multiplied by the height of column inside of house ..	30
	·2310

Thus showing a column of air 30 feet in height, at a temperature of 22°, to be nearly a ¼ lb. heavier per superficial foot than a similar column at 72° temperature.

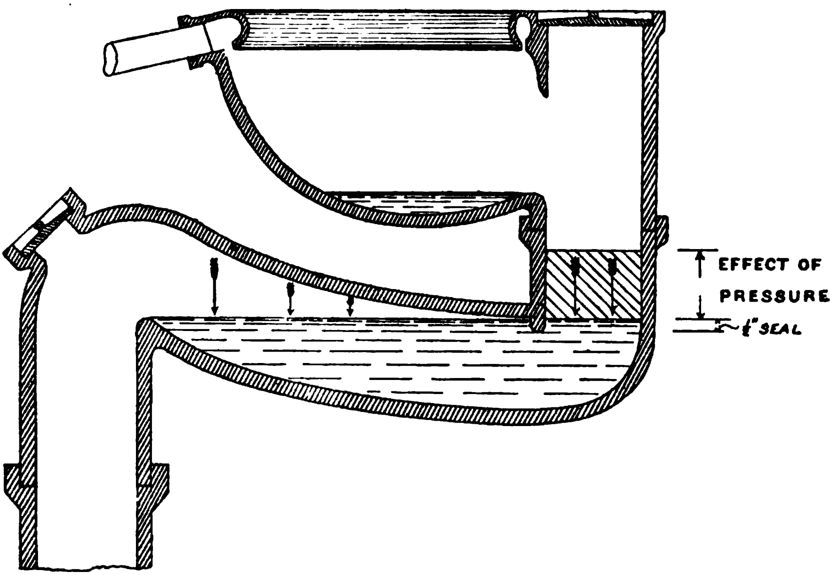
According to the same authority (table 18), the weight of a cubic foot of water at 62° = 62·321 lbs.

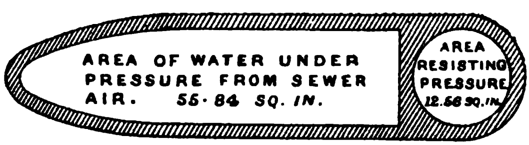
Divide this quantity by the difference of weight between the two

columns of air, and the result will represent the force or pressure on the water from the sewer air, equal to, say $\frac{62 \cdot 321}{\cdot 231} = \frac{1}{269 \cdot 78}$ part of a foot, the head of water requisite to balance the heavier column of air.

Hence, a seal half an inch deep will have a constant of safety equal to eleven times the weight acting upon the outer surface;

W.C. Trap, Half-inch Seal. One-eighth Full Size.





also, where the outer area of water is greater than the vertical discharge from the front of W.C. basin, the power of resistance will be increased in that ratio, and the danger of being unsealed by syphonage similarly reduced.

To prove the theory by experiment, some time ago I had an S-trap made of glass, $\frac{7}{16}$ inch diameter, and 2 inches depth of seal.

I then fixed this, and a gas-pressure gauge, to a tube 4 yards long, made with 4-inch sanitary pipes to represent a drain.

On the upper end a small chamber was formed of tempered clay, so that the glass trap and pressure gauge could be readily fixed.

To the lower end I applied the discharge pipe of an asphyxiator, to see whether it were possible to force smoke through the glass trap, and what amount of pressure, from within, the gauge would indicate, all other openings being effectually closed.

When the fan was driven at the greatest possible speed, the water in the trap rose and fell, and at one moment the smoke passed through, the pressure indicated by the gauge being ·05 and never reaching $\frac{1}{10}$ of an inch.

On the question of traps being forced, Mr. Haldane writes:—"During last autumn I worked daily for many weeks in a laboratory in Berlin where one or other of the traps connected with the sinks was forced every few minutes."

This could only happen by the branch drains not being ventilated close to the sink connections, but might and would occur when the sewer was wholly or partially choked a short distance below the connection with the main sewer.

A greater quantity of water from a higher level than could pass the obstruction would cause the air to be compressed. Particularly where the branch drains were rather flat, no water seal could resist the pressure.

In my own experience I have known this to occur; for instance, while flushing a sewer from a van in the street, the water in two street gullies rose above the channel, although that sewer was ventilated a short distance above where the van stood, but after the obstruction was removed this did not occur.

Much inconvenience from offensive smells may be avoided where sufficient fall can be obtained in sewers to allow a disconnecting chamber being made near to the outfall, and yet above the level of the stream into which the discharge has to be made.

Beyond this, a short length having a steep gradient can be formed to carry the sewerage below the lowest water level.

Very much of the fatty matter which the colder water causes to adhere along the sides of a sewer into which the tide flows would be carried away, which otherwise would be decomposing and generating gases to be floated towards the town, and then finding outlets at the street ventilators.

DISCUSSION.

The PRESIDENT: In the first place we are much indebted to Mr. Petree for the preparation of this paper, which is a very practical one, and the observations which have been made will, I think, be borne out by any one who has had any practical experience in the working of sewers and in making observations on the air current therein. It is popularly supposed that air in sewers is in such tension that it will often force water traps. I have made a great number of observations, and my experience bears out to the letter nearly all that is stated in the paper. Principally, the pressure that occurs in sewers no doubt is due to the expansion of air from heat; but as the variation of temperature in sewers is very limited, even in sewers ventilated by open manholes, as has been demonstrated by a series of observations made by Mr. Read, of Gloucester—48 to 54 degrees Fahrenheit—very little pressure can be exerted from that cause. The paper is important in so far as it may largely affect the construction of traps in future. Mr. Petree mentions traps being made from his point of view too deep, causing a lodgment of sewage in the trap, and consequent putrefaction. I do not think there is much in this argument, for in nearly all houses—the average house certainly—the changes of water in the trap are so frequent that most of the decomposed matter is passed into the sewer a considerable period before decomposition is set up sufficiently to create any nuisance in the house. But it would be a good thing if the members of this Association were to take the practical lesson to heart that this paper gives us, and pay more attention to this subject; for whenever anything can be done that will minimise the collection of any decomposing matter inside a house, that must be a sanitary reform that is essential and good. It is very likely, if this subject were pursued and taken up by municipal engineers, we should see the present form of traps very much modified indeed. The Association, especially the members present, should present their thanks to Mr. Petree for preparing such a practical paper.

Mr. SPENCER: I agree that we must congratulate ourselves on the very excellent paper to which we listened this morning. We must all agree, not only with the substance of the paper, but also with the remarks which have been made by yourself, Mr. President; I think they are generally on the right lines.

Of course this, like everything else, is subject to some exceptional circumstances, and I believe that if sewers remained in their normal state with regard to pressure and other things in level towns that very little nuisance would be experienced from the causes dealt with. But of course there are many towns where the gradients are very steep, and in cases of that kind it often happens that the sewers suffer from wind pressure as distinguished from air pressure. The town from which Mr. Petree comes is a flat town, but there are other towns in the north of England where the gradients of the streets are so exceedingly steep, and where the sewers follow these gradients, where the wind blows in at the grate at the lower level sufficiently to cause wind pressure at the higher levels. That, I think, is one reason why there is an outcry against the open grate system of ventilation, which has, I believe, its advantages in greater proportion than its disadvantages. The disadvantages I have mentioned may, perhaps, be dealt with by expediency, that is, that each grate must be dealt with on its merits, when it is felt to be a nuisance, by removal or temporary closure. We have frequently found that by temporary closure the nuisance dies out, and you can open it at some future time. There are exceptional circumstances arising from level position, and that is the difficulty which we have to seek to get over.

Mr. Rounthwaite: In this town we have several connections with tall chimneys, and some time ago I made experiments with these chimneys and in the sewers attached to them. I am quite of opinion that ventilation by this means is absolutely worse than useless; that these chimneys do not ventilate the sewers unless the sewers are not otherwise ventilated; but if there be separate openings or other ventilation to the sewers, the chimneys will simply draw in fresh air.

Mr. Brown: Mr. Petree says, "The gas contained in sewer air must (if it is intended to rise at all) necessarily be of less weight than the air in which it floats. Gases of greater density will undoubtedly fall, and, when in contact with the flowing sewage, will be carried to the outfall." I donot think that is correct. I think by the law of diffusion, no matter how heavy the gas, it will diffuse. If we have sulphuretted hydrogen or any other heavy gas in the sewer it will diffuse itself, and we shall feel the smell outside. As to gradients, I confess I rather like a good gradient, and strong pressure can, I think, easily be checked by

introducing valves or flaps occasionally, and so breaking it up into sections. I find no difficulty in the upper end of a district; but the great difficulty at the upper part of a town is only avoided by the introduction of these valves.

Mr. Petree.—My idea was that it was only floating matter that would give off gas that was floating on the surface. Where traps are continually flushed out there cannot be any bad smell. I am of Mr. Spencer's opinion as to wind pressure; and I think he has not understood what I was driving at. I do not think any wind pressure in sewers will ever force a trap where the sewers are ventilated. As to Mr. Brown's remarks about the diffusion of gas, gas contained in sewer air must, I am quite prepared to admit, diffuse and extend itself to a certain extent, but where there is a great density it will be more likely to be carried away by flowing sewage than otherwise.

THE SEA WALL AND PROMENADE WORKS AT ROKER.

By R. S. ROUNTHWAITE, Borough Engineer, Sunderland.

These works are perhaps the most important which have been undertaken by the Council during recent years. The scheme, though entered upon with apparent haste, was one which had, for a long time previous to its adoption, occupied the minds of many members of the Council. Towards the close of 1885 it became more and more urgent that strenuous efforts should be put forth to secure employment for the large number of workmen who could not obtain labour of any kind, and who were in absolute want of the bare necessaries of existence. Stone breaking had, it is true, been given to a large number, but this was altogether inadequate to meet the requirements of the case. A special meeting of the Highways Committee was held on Saturday morning, the 2nd of January, 1886, for the express purpose of considering how and where this surplus labour could be expended to the best advantage. The Committee resolved itself into Sub-Committees, one of which proceeded to Roker, and, after viewing the ground, and discussing the question from all points, determined to recommend the General Committee to proceed with the works which are now completed. Between Saturday afternoon and Monday morning the necessary preliminary drawings were prepared; and were submitted to and approved by the Committee on Monday afternoon, the 4th of January. A meeting was at once held with Sir Hedworth Williamson, Bart., when an arrangement was effected whereby the foreshore was conveyed to the Corporation in perpetuity at a rental of 20*l.* per annum. On Wednesday, the 6th, the Council adopted the recommendation of the Committee by 40 votes to 1, and copies of drawings with approximate estimate * were forwarded to the Local Government Board the same evening, accompanied by an application for leave to borrow the sum required.

* In a case of this kind it was of course utterly impossible to have surveys and working drawings and details prepared before the work was begun, and consequently nothing definite existed upon which to base an accurate estimate of the cost.

Representations as to the urgent nature of the application having been made to the Board, their consent was obtained without formal enquiry prior to the 15th of January, and upon that and the following day the works were set out on the ground, preliminaries being commenced with on Monday, the 18th.

Briefly stated, the works executed comprise a sea wall 1,113 feet in length, and extending from the boundary of the River Wear Commissioners Northward to the Holey Rock. Behind and upon this wall is constructed a terrace promenade and carriage drive, with approach road at the South end from the tramway terminus. The carriage-way is continued up through the Gill in the Roker Park until it joins the new road recently constructed around the park. Upon this lower terrace is a promenade 20 feet in width, formed of cement concrete, with ornamental cement balustrade, open for the most part, along the top of the wall, and which was constructed in lieu of the parapet originally intended. In the centre and at the North end are formed approach inclines from the beach to the terrace; and, in addition, there are two approaches from the beach by means of wide flights of steps up to retreats, one at the South end, and one between the centre inclines and the Holey Rock. These retreats, which were an addition to the works first contemplated, are relieving features in the line of sea wall, and an immense convenience to the thousands who frequent the sands. The carriage drive is, for its full length between the tramway terminus and the new Park Road, formed of tarred whinstone laid in three coats on a flat bedded penning or foundation of rubble, and rolled with a 15-ton steam roller. The surface drainage is provided for by special cast iron gratings in kerbs with pipe drains running through the wall and discharging on beach. The upper terrace (or Roker Terrace proper) has been raised considerably on the East side, and an ornamental cement concrete balustrade, similar in design to that upon the lower terrace, with twelve retreats and seats, has been constructed parallel with the terrace for its whole length (1569 feet) from the tramway terminus to the new stone bridge to which it is joined by a flat curve.

The promenade is here 15 feet in width, and is, like the lower, formed of cement concrete, with kerbing of Marsden limestone. That portion of the upper terrace between the tramway and St. George's Terrace, and which was formerly paved with granite chips, has been taken up and laid with broken whinstone, so that the upper carriage drive is now formed of what is termed macadam

from end to end. At the South end a part of the roadway has been relaid with whinstone random setts.

The old drinking fountain has been rebuilt with glazed bricks, and a horse trough added. A new cast iron ornamental fountain has also been placed at the top of centre inclines to beach. The positions of the street lamps have been altered and additional lamps erected. A new water main has been laid along the upper terrace and attached to a hydrant on the lower promenade. At the entrance to the park, from the new road on the West, have been erected the old iron gates and pillars which originally stood on the Wearmouth Bridge.

On the approach road to the lower terrace, as well as on the lower terrace itself, the kerbs and channels are formed of concrete in one piece, and the footpath, which is 7 feet in width, is also formed of concrete. Along the East side of this incline is fixed a light railing with cast-iron ornamental standards placed 9 feet apart (set in concrete foundations), and three rails of iron tubing.

Beneath this approach road, and on the lower terrace against the retaining wall, is formed a shelter and concrete playground, at the South end of which is a flight of steps with iron handrailing leading to the road above.

At the North end of the lower promenade, near the entrance to the park, a urinal of thirteen stalls has been constructed by and at the cost of the Health Department.

The banks have been cut away towards the South end, and made up towards the North end in order to give the requisite width of promenade and drive on the upper terrace. The positions of the old footpaths down the banks have been altered in consequence chiefly of the construction of the projecting retreats which was agreed to in March, 1886. These footpaths have also been much improved in gradient, and flights of steps have been introduced for this purpose. The banks themselves have been well soiled to a depth of about 8 inches and turfed, and this part of the work, which adds so much to the general appearance of the promenades, has not been the least expensive, owing to the great distance from which the turf was brought, namely, Marsden and the hospital site.

As in most other works of this nature, difficulties arose from time to time, but none of them were of such a character that they could not be, and were not, overcome by an additional expenditure

of money. The greatest difficulty met with was in the early part of June, in the construction of the sea wall towards the North end, where the beach is lowest and where the foundation was upon and near the rock. Here considerable trouble was experienced in dealing with the accumulation of sea and fresh water, which gathered every night and made it absolutely necessary to have recourse to pumping in order to cope successfully with the quantity which found its way into the excavations.

Although the requisite plant, such as shovels, barrows, concrete shutters and boxes, planks, etc., were got together as rapidly as possible, it was, of course, some time before many men could be started, and even when the work *was* thoroughly under way, it became necessary to suspend it on several occasions owing to the severity of the weather. Some idea of the intensity of the frost may be had when the author states that it penetrated the sand to a depth of five inches and the salt water in trenches was covered with a coating of ice from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch thick. However, in the month of March there were 180 men engaged three days in each week, and at the end of April the sea wall was practically half completed. Towards the end of September, when the heavy concreting and sand filling were nearly done, it was necessary to reduce the time worked, and three gangs of men were therefore given four days in each fortnight. During the early stages of the work several of the men employed gave much trouble and anxiety by their conduct, and it was necessary to take strong measures with a few of the leaders in order to maintain discipline. After such measures were taken, however, and the men's application for an increase of wages was acceded to, things went on to the end fairly well.

The concrete footways and balustrades were executed by Messrs. Rule Bros., of West Street. The cement kerbing and channel by Mr. Geo. Swan, of Monkwearmouth; and the carriage drives by Mr. George Scrimshaw, of Sheffield.

In September 1886, the committee met on the works, and determined to set back the foot of the embankment and to build a retaining wall at the south end of the Promenade. These alterations have been carried out, and a considerable area of unoccupied ground now remains to be dealt with between the carriage drive and the foot of embankment. It has been suggested that a restaurant, with cloak rooms, lavatories, and conveniences, should be erected upon this space, and several schemes have been con-

sidered by the committee and the council, the former having twice met on the ground with reference thereto. The feeling of the council, however, appears to be against the work being taken in hand at the public expense, but rather that it should be left to private enterprise.

A scheme has also been suggested for constructing a salt water swimming bath upon this site with private hot and cold slipper baths attached. Borings have been taken, and the position and depth of the rock ascertained, and preliminary drawings and estimates also prepared, but beyond this stage the scheme has not advanced.

DISCUSSION.

Mr. Crummack.—I beg to ask Mr. Rounthwaite if he will give us the proportions of the concrete, and also if in fixing the concrete *in situ* he had to plaster the wall on account of the bad face; and if so, how it was done?

The President.—I am particularly interested in this work having carried out on the south coast of England somewhat extensive promenade and sea defence works. The Wall we have seen this morning hardly partakes of the nature of a sea defence. In the first place, the water appears to be exceedingly shallow in the offing, and the high water level is so far from the wall at spring-tides that, only on exceptional occasions, will a heavy wave stroke attack the wall. Among the plans which are on the table, there is a section of a wall in which the nose projects almost over the toe. Some years ago I built a wall at Ramsgate to that section, with a view of throwing the water back and preventing it landing on the other side of the wall. I believe it was first adopted by engineers in the neighbourhood of Dover. That wall was about 14 feet high, and is built of Portland stone on the face of the cliff and almost identically the same as this section. We went about 4 ft. 6 in. into the chalk for a solid foundation, and the effect of the sea on that wall in ten years was such that in a number of placees the wall had to be underpinned. The wave comes up the wall, and, instead of being eased off and coming off on a slope, it is dropped down again and comes off on the toe of the wall; and I believe now the chalk is within a short distance of the bottom of the wall, and that is almost entirely due to the rebound of the water dropping on to the chalk in front of the

foundation. A little farther along on the same coast, about a mile from that wall, where the local influences and conditions are almost identical, another wall was built at the same time with a batter of about one in one, and there the scour in front of the wall has scarcely produced any effect whatever on the chalk. So that in one case with the elliptical section you have the foundation laid almost bare, and in the other, with a slope of about one in one, the foundation remaining almost intact; this affords a practical example that to erect a wall on the section shown on the plan is a great mistake. Subsequently, within the last five years, I built the promenade wall at Hove. The coast there for many years, almost from time immemorial, has been protected by a natural supply of shingle, coming from the west. On the south coast, from Chesil beach to Deal, the land is protected by shingle which travels from west to east, and, in some particular localities, that accretion of beach has been so large for the past 200 years that no system of coast defence is necessary. The beach forms itself in front of the land, and after very heavy gales reposes at a slope of about 1 in 11. In January 1880, in front of Hove, a very large denudation of the foreshore commenced. The shingle stopped travelling, from causes which were quite patent, for about 20 miles to the west a large number of groynes had been thrown out at right angles to the shore, and the natural travel of the beach was stopped. Now beach is always going away, and when stopped by artificial means the shore on the lee side is denuded. The Hove beach fell in about a year 4 feet vertically at high water mark, and where formerly there was beach sloping 1 in 11 we gradually began to get a little cliff. The first thing we did was to throw out groynes, as is always done on the south coast. These are simply wooden structures which mechanically stop the travel of the shingle and form as it were an artificial beach on the weather face of each groyne. But, unfortunately, delays occurred through the Commissioners not making up their minds and the time arrived when it was pretty clear that all that valuable property in the vicinity of Brighton, built at a cost of between two and three millions sterling, was in jeopardy of being carried away. I proposed that a sea wall should be erected. Sir John Coode was called in as consulting engineer, and with some modifications in front of the wall-line the works were ultimately carried out. The slope of that wall is 1 in 6; it is 24 feet high, and the top of it is 12 feet above high water mark. When we had put up about 300

feet in length of the wall, we had already lost, as I have told you, a very considerable amount of shingle, and there was a reflex action set up to such an extent in front that the beach was carried away to within 10 inches of the bottom of the foundation. That, of course, was a very serious position in which we found ourselves, and immediately where the beach had been scoured away by the reflex action set up we began to close pile the wall. The driving of 12-inch piles through 12 feet of shingle was a heavy work. We tried green beech, oak, and pitch pine, and we found that no material would stand except pitch pine. The green beech gave way, and the oak became mop-headed, but we found that pitch pine was invaluable. Even with green heart piles we found they split. The piles were driven with a ton monkey, and with a drop of 7 ft. 6 in., and 24 blows to the minute. We had hardly finished the piling at a great expense, going on with our groynes to intercept the shingle, when one fine morning the piles were buried, and have never been seen from that day to this. But we had taken another precaution which was unique, and which is interesting as showing the effect of the wind on the travel of shingle. We brought from Shoreham 25,000 tons of beach in hopper barges, deposited it about 400 feet from high water mark at sea. During the summer months there it lay in heaps, gradually flattening down. In some photographs I have, the heaps may be seen just above the water at low water. When the autumnal equinoctial gales came on, the whole of that beach was brought in to the front of the wall. Not a stone remained outside, and although the prevailing winds at Brighton are at an angle of about 30° to the line of the wall, the whole of the deposited shingle came in at right angles to the spot where it was dropped, and every stone that was deposited in front of the wall is now lying in between the groynes protecting it, the depth on the face of the sea-wall being about 8 feet vertically. The consequence is that there is the wall remaining, with the expensive piling buried, and the beach is lying close up to the wall, in many places only 5 feet from the top of the wall. There is a curious action set up with regard to groynes on the south coast, and I suppose it maintains on all foreshores—the difference between the weather side and the lee side. I have often watched the effect during gales, the scour on the lee side is marked to a greater extent after very heavy weather. I shall be glad to hear from Mr. Rounthwaite whether the extension of the pier, has increased the depth of sand, and I should also like

to hear from him what height the sand or material that travels along this shore, is thrown up above high water. At Brighton, high water is 10·77 feet above ordnance datum. After gales the shingle is thrown up to 29 feet above ordnance datum, by the action of heavy weather on the travelling shingle. Before I sit down, I think I ought to express our thanks to Mr. Wake, the engineer of the pier, who has shown us that work. It is an exceedingly interesting piece of engineering, and I say this having seen some of the greatest harbour works in the world. I was lately over a harbour on the south coast, and it was a most striking contrast as compared with the Sunderland works; where one could not but be struck with the neat way in which the work is being carried out, by the way in which the blocks are made and placed in position, the admirable design, the beautiful lines, and the accuracy with which the work is executed. These all reflect the greatest credit upon the engineer.

Mr. Spencer.—I also beg to express our gratification at what has been shown us this morning, and to acknowledge the advantage that the inspection of such works as these must be to members of the Association. Of course, the very large and important works make the promenade and sea-wall somewhat subsidiary, but they are a great attraction to the neighbourhood, which has seen many changes for the better during the last few years. No one can have seen those works which we had the opportunity of inspecting this morning, without acknowledging the superior engineering talent which has been brought to bear in both instances The breakwater is of the highest interest from every point of view. not only from an engineering point of view, but from the excellent and complete manner in which it is being carried out. The forethought and provision for contingencies, which is one of the greatest points of engineering, are especially worthy of praise. The work itself will be a monument to Sunderland and to the men who are carrying it out when they have long passed away, and, when completed, the pier will be a credit to the whole of the east coast. Roker, some years ago, was a mere row of houses on a bleak beach of sand hills, and it was only by going to the picturesque rocky coast beyond that any gratification could be obtained, but now all that has been changed by the liberal action of the Corporation of this borough and the excellent manner in which the work has been carried out.

Mr. Petree.—Some years ago, when the south dock was

at Sunderland, there were groynes carried out there, and I remember that on the dock side they were sometimes above my head and I had to climb over them. Some years afterwards they were all level on the north side.

Mr. H. H. Wake.—I have not come prepared to speak but after the very kind remarks which have been made I feel compelled to rise. In the first place I beg to thank you for the words in which you have expressed your thoughts in regard to the works which you were over this morning. I feel that I should like to compliment Mr. Rounthwaite on the way in which the sea-wall and promenade works were carried out. I saw them in progress, and can say that they reflect the highest credit on him considering the weather and difficulties he had to contend with. I am very much surprised that the work has stood so well, and it shows the amount of care and attention that was bestowed upon the construction of it. As to the seas passing over the pier, I may tell you that last Wednesday when we had a rise of tide of 18 feet with a heavy gale, the pier was for four hours entirely under water and buried with spray. It is not constructed as a promenade, but for a breakwater. The south dock here, I may say, was formed by putting down groynes. The docks themselves were entirely made out of the sea, and the west side of the dock was the line of the old sea coast. Sunderland was the first place where the accumulations of beach were thus utilised, and the engineer was Mr. John Murray. We find here that if we want to accumulate a beach that the space between the groynes must be equal to their length. As to their being deeper on one side than the other, I think it is due to the eddies.

Mr. Brown.—As to the concrete walls, I should like to know the proportions of Mr. Rounthwaite's mixture. We have had difficulty with the cracking of the concrete. I should like some information also about the tar macadam, as there is a great deal of controversy about it at present. I think it a great improvement on ordinary macadam.

Mr. Rounthwaite.—As near as I remember the concrete was mixed in the proportion of between 8 and 9 to 1. The hearting was formed of granite, freestone, and various kinds of rubble. The wall facing was finished off with cement and sand, where necessary, as the work proceeded. It came out very clean from the boards, but required doctoring as we went along. With regard to the wall generally, I think it fair to say that Mr. Wake himself

has had more to do with the scheme than most people are aware of. I am not sure but that its inception was due to him many years ago. He gave me great assistance in arranging the line of the wall and in the construction of it, and I take this opportunity of expressing my obligations to him for what he did. It is not intended as a sea defence, but simply as a promenade and carriage drive, and to encourage people to visit the place. It has been highly successful in that respect, many thousands of people going down every summer. I have known the tramways company carry in one day upwards of 80,000 persons, and there would be four or five times that number down at the sea-side. There is no question but that the construction of the pier has caused sand to accumulate to a very large extent between the pier and the Holey Rock. As to the concrete footpath, the bottom is formed of broken brick 6 inches deep, and the footpath 1¾ inches of cement and ballast (4 to 1) and ¾ inch of cement and crushed granite (2 to 1) and cement in equal proportions. The tar macadam is made of broken whinstone. The cost was 2*s.* 3*d.* per yard, exclusive of foundation. It was done by contract by Messrs. Scrimshaw, of Sheffield, and some skill was required in getting the tar of a proper consistency. The cost of the whole of the works and forming the road through the park was roughly £10,300.

SUNDERLAND HOSPITAL ACCOMMODATION.

By R. S. ROUNTHWAITE, Borough Engineer, Sunderland.

One of the most important questions of the day with which sanitary authorities have to deal is, without doubt, the provision of hospital accommodation for patients suffering from any infectious disorder, and where such cases may be perfectly isolated from the rest of the community.

This subject is, moreover, one of *growing* importance; and, where such accommodation has not already been provided, it is occupying the serious attention of health authorities.

It is now some few years since it became apparent to the Corporation of this Borough that the present hospital, or, as it is termed, "House of Recovery," was totally inadequate to serve as an hospital for a town of this magnitude; and, after considering schemes for the extension of the old building, determined upon the purchase of a site in one of the outlying districts; and upon the erection of a new building.

With this object in view many excellent sites were examined by the Health Committee, and eventually, that in Hylton Lane was purchased, in February 1885, from Colonel Scurfield for a sum of 5000*l.*

This site is about 12 acres in extent, measuring 1050 feet from North to South, and 500 feet from East to West, and is within easy distance of the centre of the town, being but 2 miles and 142 yards from the intersection of High Street West and Fawcett Street. It is admirably situated for the required purpose, sloping gently from the East to the North, West, and South sides.

Before entering into the question of the class of buildings to be erected, the Corporation built around three sides of the site a substantial wall of 9-inch brickwork in cement mortar with counterforts on each side:—This work was executed in English bond on a foundation of Portland cement concrete, and finished with red brick saddle-back coping.

I may here mention, as it frequently happens that difficulties are thrown in the way of health authorities in the selection of

sites for this class of hospital, that no objection was raised by any of the neighbouring owners until the inquiry into the application for leave to borrow the sum necessary for the *buildings* was held, when two objectors appeared. The inspector sent by the Local Government Board very properly informed these gentlemen that they should have raised their objection when the inquiry was held as to the loan for the purchase of site and building of boundary wall.

A very great deal of time has been spent by the Committee having charge of this question in the consideration of the laying out of the ground, and of the class and nature of the buildings to be erected thereon. A deputation visited Glasgow in September 1885, and minutely inspected the arrangements of the Belvedere Hospital. In the following month the deputation also visited Sheffield, Manchester and Salford (Monsal), Bradford, and Darlington, where they had the advantage of examining the arrangement and working of the hospitals at these places.

The Council approved of the scheme submitted by the Health Committee on the 14th of April, 1886. On the 8th of July following, the public inquiry was held by Mr. Arnold Taylor, C.E., and the sanction of the Local Government Board was shortly thereafter obtained. The tender of Mr. T. P. Shaftoe, of this town (13,796*l.*), was accepted, and the work was commenced in the latter part of March 1887. (The contract drawings, specification, and quantities are upon the table).

The site plan shows the general disposition of the ground, buildings, roads, main drains, gas and water-pipes, etc.

Prior to the commencement of the contract, that portion of the land which was not required was permanently enclosed with a strong fence, 500 yards in length, consisting of angle iron standards fixed 4 feet above the ground, short intermediate standards, straining pillars, etc., and seven galvanised steel wire ropes. This work was executed by Messrs. G. B. Smith and Co., of Glasgow, at a cost of 46*l.*

The excavation for, and foundation of, the main drive from Hylton Road to the site of Administrative block was also completed beforehand by Mr. J. T. Simpson, of Newcastle, at a cost of 60*l.*

The buildings which form the hospital, consist of (*a*) The Administrative block; (*b*) The Washing, Laundry, and Disinfecting block; (*c*) The two Fever pavilions; (*d*) The Isolation

pavilion; and (*e*) The Entrance lodge. In the *Administrative Block* there are provided, on the *ground* floor: dispensary, medical officer's bed and sitting rooms, waiting room, nurses' dining room, matron's sitting room, sewing room, four store rooms for clothing, etc., servants' hall, kitchen, scullery, dairy, larder, lavatories, and the usual out-offices. In the *basement* are two cellars for wine, beer, etc. On the *first* floor there are: sitting room for nurses, and bedrooms for matron and ten nurses, together with linen store, bath room, w.c., and housemaid's sink. On the *second* floor are nine dormitories for servants, with linen store, bath room, etc., as below. This building is designed in the form of the letter T, with kitchen department in the centre and rear, so that in the future it may be extended, if necessary, in the form of a quadrangle. The length of the west frontage is 100 feet, and this part is two stories and a half in height, whilst the wings are two stories, and the kitchen and offices one story only.

The Fever Pavilions are one story in height, and each contains two large wards for male and female patients, which more than fulfil the requirements of the Local Government Board with regard to floor and air space. Each ward will accommodate eight patients, and is 48 feet long, 26 feet wide, and 13 feet high. They are heated by means of large central hot air gill stoves with double fires and descending flues, and, in addition, by hot-water pipes. The vitiated air will be extracted by means of specially constructed, funnel-mouthed, zinc ducts, surmounted with Boyle's patent air-pump ventilators. For the same purpose are provided outlets into foul air flues in external walls and adjoining the flues from stoves. The windows are double hung, with deep bottom rail to admit fresh air at the meeting rail without draught. Over these windows are hinged lights which open inwards at top, and under each bed is a fresh air inlet.

At the extreme end of each ward is situated the annexe containing the necessary conveniences. This annexe is completely cut off from the main building by a short passage with cross ventilation, and is heated by a hot water radiator.

In the centre of the building is the nurses' duty room, overlooking each ward; also the bath rooms, pantry, and coal store.

The Isolation Pavilion has been erected mainly for the purpose of accommodating cases in which it is not always possible in the early stages to be positively certain of the precise nature of the disease. For this building the Local Government Board submitted a plan of

which they approved and which they wished to be adopted in this case, but on representing to the Officers of the Board the character of the site and climate, they permitted material modifications to be made. There are four wards in this pavilion, two with two beds, and two with three beds, and it may frequently be convenient to use some, or all, of these as private or convalescent wards, or for typhoid cases.

This building is, like the other pavilions, one story in height, and is provided with nurses' duty rooms, conveniences, etc. The wards are heated and ventilated in a manner similar to the larger wards previously described.

The floors of all the wards are laid with narrow pitch pine boards, screwed down and beeswaxed; and the walls and ceilings are finished in Parian cement on a base of Portland, all corners and angles being rounded out to prevent the lodgment of dust.

The Washing, Laundry, and Disinfecting block.—The ranges of one-storied buildings to the South of, and adjacent to, the Administrative block, together with the enclosed court yard, cover an area of 636 superficial yards, and comprise disinfecting rooms, wash house, drying closets, laundry, stable, hay and straw store, ambulance house, boiler house, post-mortem room and mortuary.

The clothes, etc., required to be disinfected, are brought in from the main drive near the South-East corner, and passed through the Lyon's steam disinfecting apparatus, which is 7 feet by 6 feet by 3 feet 7 inches, into the adjoining chamber. They are then conveyed across the court yard to the wash-house (which is divided into two parts), washed, placed in the drying closet, then passed on to the laundry, and out at the opposite or North-West corner of the block.

In the boiler houses is erected a vertical steel boiler, 9 feet high by 4½ feet diameter, which will supply steam to the disinfector, wash tubs, drying closet pipes, and the copper calorifiers under each building. Adjoining the boiler, and connected with the same chimney, is the furnace destructor, into which will be thrown all infected bedding and other matters which it is deemed necessary to destroy.

I may here add that it is the intention of the Committee to construct, at once, a chimney 55 feet in height, in place of the present one.

In the wash-house there are provided six tubs, with cold water and steam supply, washing machine, hydro-extractor, and wall pump, connected with large rain water tank under court yard.

This tank is 16 feet by 10 feet by 5 feet deep, and contains 5,000 gallons. It is built of brickwork on concrete foundation, cemented and arched over top, with proper provision for access. It is supplied from the roofs of the adjoining buildings, through a filter chamber constructed at one end.

The drying-closet is provided with five galvanised wrought-iron horses upon runners and rails. It is divided into two parts and heated by means of steam pipes, with the usual provision for the ingress of fresh air and for the extraction of moist air.

In the laundry there is provided ironing stove, mangle, and radial horse for the airing of clothes.

In the stable there is accommodation for two horses; and, in the ambulance house, for two conveyances with access from either side.

The Entrance lodge, etc.—This lodge, with entrance gates, has been erected at the north-east corner of the site adjoining the Hylton Road. It is a single-storied building, with timbered gables, and contains four rooms and a scullery, with meter and tool houses, and out-offices in yard.

The entrance gates are of wrought iron, with piers built of brickwork in cement, and stone caps and dressings. The Northern boundary wall along the Hylton Road frontage has been set back to a line 20 feet from the centre of the old road, and is built of 14-inch brickwork, panelled and ramped, and finished with a triangular red brick coping similar to that upon the other boundary walls.

The drainage has been carried out on the lines shown upon site plan, and exceptional difficulty was experienced in this work owing to the extent and hardness of the limestone rock met with in the cutting. The main drain has a gradient of 1 in 70, and is provided with ample means for ventilation and for access. At the head of the system is constructed a flushing tank, with Adams' patent automatic syphon, which can be adjusted so as to discharge 750 gallons of water, and disinfectants, at such intervals as may be deemed necessary.

The roads have been pitched with hand-packed rubble and covered with smaller material of the same description. On the completion of the works they were coated with marl, rolled, and spread with fine gravel.

The gas and water mains, pillar hydrants and lamps, have been laid and erected in the positions indicated by the plan, and the

Gas Company continued their main in Hylton Road to the site on payment by the Corporation of 100*l.*

The whole of the works have been laid out and designed with the view of obtaining a thoroughly substantial, yet, at the same time, economical establishment. The buildings are of the plainest character and free from all unnecessary ornamentation. They have been erected with Sherburn House and Birtley bricks, on cement concrete foundations, with dressings and strings of Prudham stone, and steps from Heworth Burn quarry. The red bricks for plinth courses and relieving arches are from Grosmont, near Whitby; the buff bricks in band courses from Wortley, near Leeds; and the roofs are covered with strong Port Dinorwic slates, machine holed, and fastened with copper nails on boarding. The external walls are built hollow to ensure dryness and warmth, and the whole of the sites of the various buildings are covered with 4 inches of cement concrete.

I regret that no part of the buildings has yet been furnished, but the Committee are at present engaged in making arrangements for this to be speedily done. The total cost of furnishing will not exceed 1,200*l.* to 1,300*l.*

The Members proceeded by brake to Roker, where, under the guidance of Mr. R. S. Rounthwaite, the Members inspected the Sea Wall and Promenade works, where they were met by Mr. Henry H. Wake, Engineer to the Wear Commissioners, who kindly conducted the Members over the new Pier works now in course of construction. Returning by brake the party had lunch at the Grand Hotel, after which, under the guidance of Mr. R. S. Rounthwaite, the Members visited the new Fever Hospital, and returned to the Committee Room for the discussion of the papers.

Cordial votes of thanks were accorded to the authors of the papers, to Mr. Wake for showing the Members over the New Pier Works at Roker, to Mr. Ellice-Clark for presiding, and to the Mayor for the use of the Committee Room.

DISTRICT MEETING AT SOUTHAMPTON.

May 4, 1889.

Held in the Municipal Buildings, Southampton.

Mr. E. B. Ellice-Clark, *President, in the Chair.*

The Mayor of Southampton (Alderman Coles), having very cordially received the members, the meeting was held in the Council Chamber, where the business commenced by the election of Hon. Secretary for the Home Counties District.

On the motion of Mr. Eachus, seconded by Mr. Norrington, Mr. O. C. Robson (Willesden), was re-elected Hon. District Secretary.

The following papers were then read.

THE UTILISATION OF "TOWN REFUSE," SEWAGE DISPOSAL, ELECTRIC LIGHTING, AND CONCRETE PAVING AT SOUTHAMPTON.

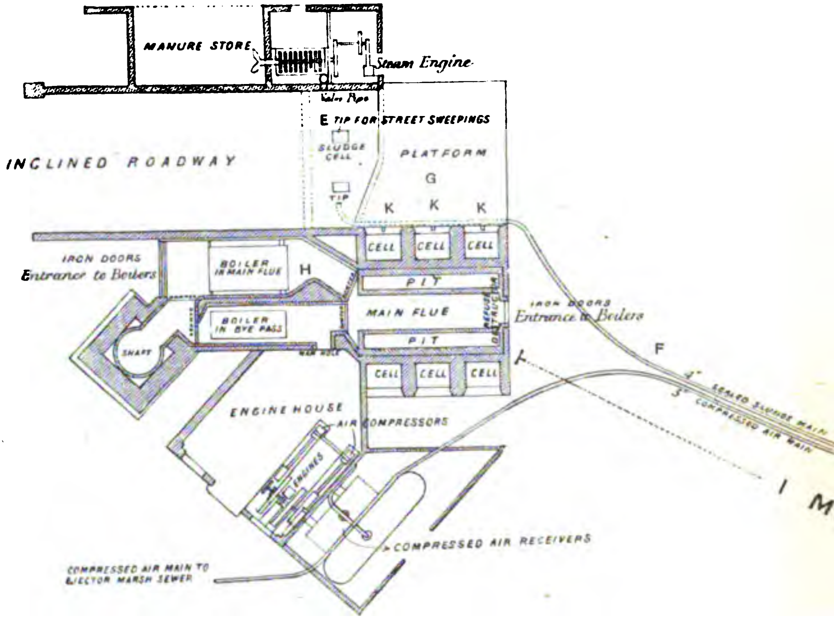
By W. B. G. BENNETT, Assoc. M. Inst. C.E., Borough Surveyor, Southampton.

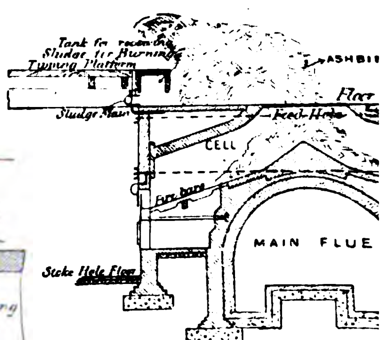
The object of my paper is to give a description of the New Sanitary Works, recently carried out in this Borough, which I shall have the honour of showing you later to-day.

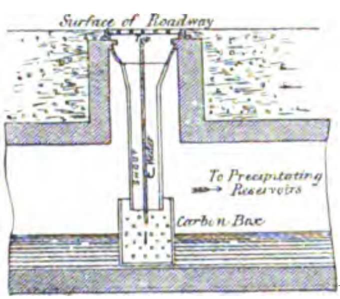
In Southampton we have, what is common to nearly all towns in the kingdom, our Sewers, Sewage, and Refuse—subjects with which you, the members of this Association, are so conversant and know so much about, that I am certain it would only be presumptuous on my part to attempt to place anything in connection therewith before you and call it new or novel.

I intend therefore in describing these works to give you plain facts as briefly as possible, owing to the short time at my disposal.

Early in 1885, my Corporation considered it expedient to

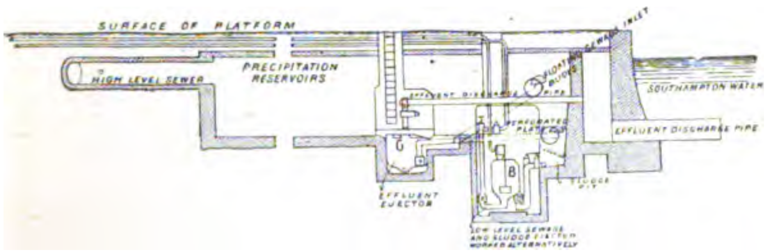


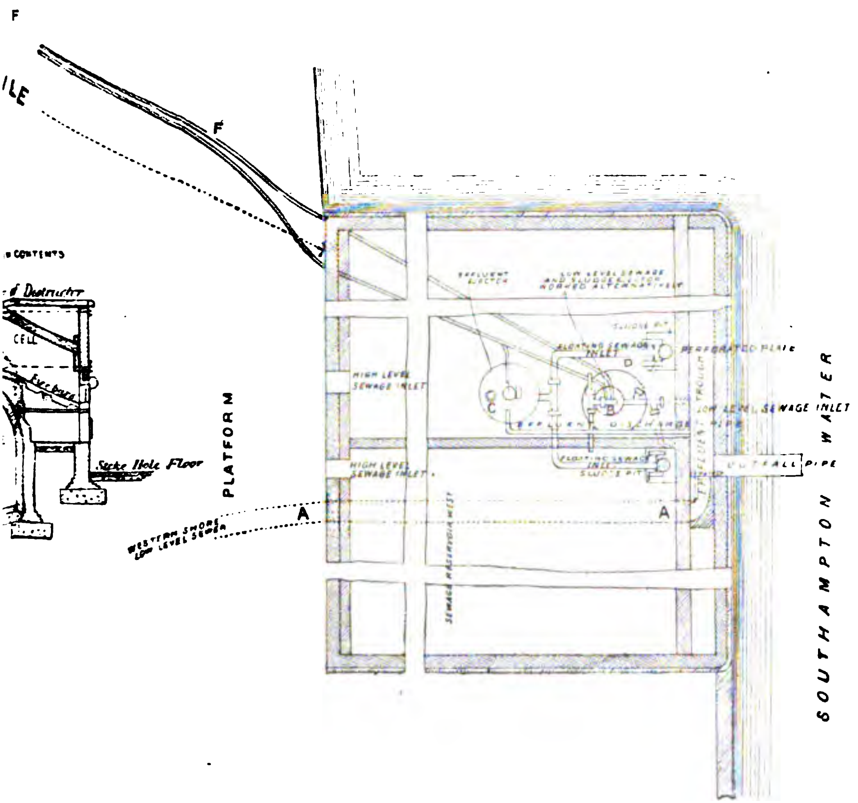




CARBON BOX AND SHOOT

ON SEWAGE WORKS.





introduce a more efficient system of collection and disposal of house refuse, and about the same time they found it desirable to clarify the sewage of a district of the town, which was discharged into the Southampton Water at the Town Quay in its crude state.

I was instructed to devise a scheme to accomplish these objects, and accordingly proposed the adoption of Messrs. Manlove, Alliott, Fryer, and Co.'s Refuse Destructor, to serve the double purpose of destroying the ash-bin contents and garbage, and of disposing of the sewage-sludge deposited, in the process of clarification, in two existing reservoirs adapted for the purpose. Formerly the sewage of a district of the town, amounting to 500,000 gallons in twenty-four hours, from a population of about thirteen thousand, for the most part flowed by gravitation into these reservoirs, from whence it was discharged into the tideway at low water; whilst a small portion, coming from a low-level sewer, passed through iron pipes A A*, laid under the reservoirs, direct into the tideway. The reservoirs act alternately, one being left still for precipitation of the sewage, whilst the other is being filled.

In order to render the discharge of the effluent from the reservoirs independent of the tide, and to raise the low-level sewage into the reservoirs for treatment with the rest, two of Shone's pneumatic ejectors were put down, one of 360 gallons capacity, B, placed below the invert of the low-level sewer, which serves for discharging the sludge as well as for raising the low-level sewage; and the other, of 700 gallons capacity, placed in the east reservoir at C. In each reservoir there is a floating sewage inlet, D D, consisting of a pipe connected with the large ejector, and shackled to a buoy, which makes the pipe rise and fall with the water-level, keeping its mouth, which is covered with a perforated plate, a few inches below the surface of the effluent, to prevent the passage of any floating matter. Directly the clarification by precipitation has been effected to a certain depth, a valve is opened, admitting the effluent into the ejector C, whence it is at once discharged into the tideway. A supplementary sewage outlet is also provided in each reservoir for discharging the effluent by gravitation when the tide is low enough. When the whole of the effluent has been thus drawn off, the buoy, resting now upon the floor of the reservoir, keeps the mouth of the inlet sufficiently high to prevent the admission of any sludge; and the sludge is then admitted into the

* The illustration attached has been kindly lent by the editor of 'Industries.'

ejector B, by opening a valve, and is transmitted by pneumatic force through a line of 4-inch cast-iron pipes F F F, nearly a mile in length, to the destructor erected on the Chapel Wharf at G.

The sludge is discharged into a cell, E, from whence it is drawn as required through a valve-pipe, and after mixture with road-sweepings or sorted house refuse, in an incorporator, is transmitted by a specially arranged conveyor to an elevator, which loads it into trollies, as a good dry portable manure, which has all been readily bought up by agriculturists, since the commencement of the works at 2s. 6d. per load delivered at the works. A six horse-power steam engine drives the incorporator and elevator. On an average, sixty cartloads of ash-bin contents are daily collected and disposed of. Twenty-five tons of refuse, when burnt, generate sufficient steam for the carrying on of the works for one day. The road-sweepings are never burnt. In wet weather the road-sweepings are stored and dried; and the fine ashes from the destructor are incorporated with the sludge in their place; but frequently during the winter, to keep pace with the demand, the sludge is run into bays made of, and filled in with, the road-sweepings.

The refuse destructor has six cells or furnaces, each capable of burning eight to nine tons of garbage per day. The products of combustion pass through a 30 horse-power multitubular steel boiler, H, in the main flue, to the furnace shaft, which is of circular brick-work 160 feet in height from the ground line; inside diameter at the top 6 feet, ditto at the bottom 7 feet, constructed upon a pedestal 14 feet 6 inches square, and 24 feet in height, of brick-work 3 feet thick, then in four sections as follows:—

1st, in 27-in. brickwork	.. ..	30 ft. high
2nd, in 22½-in. ,,	.. ..	30 ,,
3rd, in 18-in. ,,	.. ..	38 ,,
4th, in 14-in. ,,	.. ..	38 ,,

The first 30 feet is fire-brick, lined, with a cavity of 4½ inches behind, ventilated to the outer side.

The foundation is loamy clay, upon which is laid a bed of concrete 30 feet square and 10 feet thick.

The footings commence at 23 feet 2 inches square, and step off in regular courses up to 15 feet square, at a height of 6 feet. The concrete was filled in continuously until completion. The pedestal was then run up and allowed to remain for nearly three months during the winter, after which the works proceeded until completion, which occupied about six months.

The cap is white brick in cement, with a string course about 20 feet below the top.

Foot irons are built inside in a winding lead to the top.

The shaft is provided with a copper tape lightning conductor, with inch rod and crow's foot 7 feet above the cap. The tape is about 215 feet long, the end being carried into a well.

In August last the shaft was damaged by lightning, but was easily repaired, owing to the provision of the foot irons referred to. At this time the shaft was plumbed and found to be quite vertical. The fires were only damped down during the repairs, which occupied about eight days. With the exception of this interval they have been constantly burning for nearly three years.

The repairs have been almost nil.

There is also a by-pass in which a smaller boiler is placed, to enable the works to be continued during cleaning and repairs. No obnoxious fumes from the combustion have been perceived. The steam generated in the boiler is employed for driving a pair of engines of 31·5 indicated horse-power, which compress air into two large receivers, whence it passes in a 5-inch main to the Town Quay, where it is automatically supplied to the ejectors when required for working them; and it also serves for driving the precipitated sludge through the main to the destructor, before referred to, being led from the receiver by a pipe to the head of the main at the Town Quay, and also the six horse-power engine.

All obnoxious matters are collected throughout the borough in specially constructed, covered, iron tumbler-carts, which go up the inclined roadway approach to the destructor, and discharge their contents out into the cells. The road-sweepings are discharged into a hopper over the incorporator, and are mixed with the sludge as required.

The residue from the continuous day and night combustion consists of about 20 per cent. of good hard clinkers and sharp fine ashes; the clinkers are used for the foundation of roadways and the manufacture of paving-slabs, which have already been used in paving several foot-paths of the town, at a cost of 2*s.* 6*d.* per yard; the fine ashes are also employed for mortar. Porous carbon is used for precipitating the sludge; it is mixed with 1 lb. of sulphuric acid per cwt. and clean water, into a stiff paste, and led through a shoot, I, into a box, J, with perforated sides, placed in the sewer. The sewage flowing past washes the carbon gradually out of the box, and is thoroughly mixed with the carbon by the time it discharges

into the reservoirs at a manhole 150 feet off. A small stream of water falling down on the carbon prevents it consolidating. The box is filled three times in twenty-fours; and this method of dosing the sewage has proved quite efficient and satisfactory. A pressure of air of 40 lbs. on the square inch is required for working the sludge ejector, and 10 lbs. for the effluent ejector. Eight tons of sludge are dealt with per day; and arrangements were provided for burning the sludge. The sludge was discharged into a tank on the floor of the destructor, and drawn out through ports K K K, in the front opposite the feed-opening of the cells, where its moisture was absorbed by the ash-bin contents, backed up against the ports with this object; and the mixture was then raked into the fires. Large quantities of sludge have been thus destroyed; but the process has been discontinued owing to the ready sale of the sludge when prepared for manure. There is also a third ejector of 360 gallons capacity, which deals with the sewage of another district of the town near the works, operated also by the destructor, which raises the sewage from a low-level sewer to a higher one about 18 feet above, the compressed air required being 12 lbs. to the square inch. This ejector was formerly worked by an independent steam engine, costing for coals about 120*l.* per annum, which is now saved.

The waste heat from the destructor is also utilised for producing electricity. The engines before referred to drive a dynamo sufficiently powerful to feed either ten arc lamps of 3000 candle-power each, thirty 1000 candle-power, or two hundred glow lamps of the ordinary 16 candle-power type. At the present time the works are lighted with two 3000 candle-power and 12 glow lamps, and frequently four streets in the vicinity of the works are lighted, but this has only been done experimentally for the information of the Corporation, who have, from the successful results obtained, unaminously resolved to extend the installation to the Municipal offices (the building we are now in); the Hartley Institution, just below here; the Town Hall, at the Bar Gate; and the church clock opposite. For this purpose accumulators will be placed in the basement of this building, and charged through a cable from the works. This lighting will be more economical than the gas, as it will be seen no cost will be incurred for fuel, as we have ascertained that the house refuse will be sufficient to maintain the steam. I may also mention, in order to show, what further use can be made of a refuse destructor and the utilisation of town refuse in connection with sewage treatment, that nothing will be

easier for us, as soon as Mr. Webster has perfected his system, than to employ it for the electrical treatment of our sewage; for we shall only have to place the electrodes in our existing reservoir, and charge them from the dynamos at the destructor works by cable, thus saving the cost of our precipitating material.

Whilst upon the subject of artificial lighting, I may mention that I have recently given considerable attention to the employment of "hydrocarbon oils and compressed air for lighting towns or districts," and have devised a scheme in which the destructor forms an important adjunct. I will briefly explain the system to this Association as another example of the utilisation of town refuse.

I proceed in the following manner:—I erect a station or stations in any suitable place; and I compress air, and transmit it through iron mains and services laid in the ground to hydrocarbon oil burners attached to the ordinary street lamp columns; and at the same station or in any convenient place I construct receivers for the hydrocarbon oil, which I also transmit through separate mains and services to the burners before mentioned, or to any other point of combustion required. These oil mains and services are kept charged by a Shone's ejector, which as you know is operated by the compressed air, and the ejector, being automatic, regulates the flow of oil to the burner, according to the demand made by the consumption in burning; any number of lamps can be supplied from one station. I lay the oil main within the air main, an arrangement whereby the oil is kept at a higher temperature. I have made several experiments with this method of lighting and am continuing them, but I regret the time at my disposal to-day will not permit me to enter more fully into the details.

The result of my proceedings have so far led me to anticipate that at no distant date I shall be able to show this Association a district of a town lighted under this system, and worked entirely by a refuse destructor, consequently much more economical than any artificial light hitherto employed for public lighting.

Our destructor is also to be employed to give a helping hand to a neighbouring authority.

The Corporation have agreed to supply the Local Board of Shirley and Freemantle, about two miles from here, with sufficient compressed air to work an ejector which they are about to put down in connection with the disposal of their sewage sludge by

precipitation. The compressed air will be conveyed through a 4-inch main from our works to theirs, thus saving them the cost of a pumping station, and bringing to us a return of 200*l.* a year, which they have agreed to pay for the compressed air.

The initial cost of the destructor, including engine house, inclined roadway, chimney shaft and boiler, and ironwork complete was 3723*l.*; and the sewage disposal portion of works about 3000*l.*

The annual expense for burning refuse is as follows:—

	Per Week.	Per Annum.		
Two stokers, 1*l.* 5*s.* each, 1 day and 1 night	2 10 0	182	0	0
One feeder, day only..	1 0 0			
Half time of superintendent		39	4	0
		£221	4	0

Maximum quantity burnt per day of 24 hours for the last three years is fifty tons, which is less than 3½*d.* per ton for burning.

The minimum quantity burnt per day of 24 hours is about twenty-five tons.

This quantity has maintained the steam for the purpose of our work for 24 hours. The indicated horse-power of the engines being 31·5, or ·80 of a ton of refuse per horse-power for 24 hours, or 75 lbs. of refuse per horse-power per hour.

The annual expenditure for the sewage clarification and disposal works is 308*l.*, as follows:—

	£.	s.	d.
365 days (carbon precipitating material average 8*s.* 2*d.* per day)	149	0	0
Labour attendants at reservoirs	65	8	0
Two men at wharf manure mixing	93	12	0
Total	£308	0	0

The amount received from the sale of the manure during the last year is nearly 600*l.*

The products from the destructor, which includes the concrete slabs before referred to, steps for police station, clinkers used for concrete foundations, fine ashes for mortar and foundations for footwalks, and clinkers sold for new cycle track, represent about another 300*l.*

To which could also be added the saving for coal required for working the engines.

DISCUSSION AND VISIT TO WORKS.

Mr. J. Lemon: I am very pleased to see so many friends at this meeting of the town of my adoption. While we are all very much interested in Mr. Bennett's paper, the members are placed at this disadvantage—they have heard the works described, but they have not seen them; we should, therefore, for the present confine the discussion to the general principles only, and then, after we have all seen the works, we can go more into details. The Corporation of which I am a member, some time ago were very much impressed by the nuisance of the accumulation of refuse in certain parts of the town, arising in this way—the contractor was unable to sell it at certain seasons of the year, and a large amount of matter was left. They decided on a refuse destructor, and experience has proved that they did the right thing. But it meant money, and you cannot improve the sanitary works of any town without paying for it. The cost of removing the ashes before the destructor was used was 650*l.* a year. It is something like double that now, but of course it is better done, and against the increased cost we have to set the motive power; we have the destructor, and if Mr. Webster can only perfect his purifying process, it will be a great step in dealing with refuse sewage.

Colonel Jones, V.C.: Great credit is due to Mr. Bennett for having done so much towards solving the difficulty of utilising the waste product of town sewage. This is acknowledged to be of the greatest importance. No doubt Mr. Bennett has found the services of Mr. Lemon of great value, and the town is to be congratulated upon putting so eminent an engineer upon the Council. It is an example other towns should follow, because the disposal of town refuse requires so much more attention than an ordinary town councillor is able to give.

The company then proceeded to the platform on the Town Quay to inspect the sewage outlet, where the sewage is precipitated, the effluent passing into the Southampton Water.

Mr. Bennett explained that they were there standing upon two reservoirs, 100 feet long, and 60 feet wide, and at the lowest end 10 feet deep. Directly the clarification by precipitation has been effected to a certain depth, the effluent is discharged into the tide-way. Afterwards the sludge had to be dealt with. It is admitted into the ejectors and thence transmitted by pneumatic force to the destructor about a mile away, and there mixed with the

road sweepings and house refuse, when it becomes a marketable commodity and is readily sold. Porous carbon is used in the precipitation, and at present they were using about 3 cwt. a day, at a cost of 3*s*. 6*d*. per cwt. The sludge in twenty-four hours was about eight tons. These reservoirs were not constructed to take the whole of the sewage of the town. It only treated a district of of 13,000 or 14,000 inhabitants, and was very successful. We get the carbon from the Porous Carbon Company. Replying to further questions he said after the effluent had been disposed of, the solids were dealt with at the works. Their object was not to get an effluent of a very high standard, but only to keep the solids out of the water. Paper, corks, and such like, were collected by a screen. The sealed main was five inches in diameter and a mile long. With regard to the leakage of the mains, Mr. Bennett said he had found no difficulty so far.

Mr. PRITCHARD: I have had mains tested before laying, and although some only lose half per cent. in half-an-hour, some lose 13 and 14 per cent.

Mr. BENNETT: Each of our pipes were coated with a solution of soft soap, and tested with compressed air at the time of laying.

The PRESIDENT: If you test your pipes with air to three times the pressure that will be used, it is better than water pressure. With copper pipes with copper washer and steel bolts, I have worked pipes to a very high pressure, but I now prefer to use weldless steel pipes.

Mr. BENNETT: We have found no loss from our joints.

The visitors were then shown the carbon box in the main sewer, into which a small stream of water falls to prevent the carbon consolidating. The box is filled three times in twenty-four hours. The sewage flowing past washes the carbon gradually out of the box, and is thoroughly mixed with the carbon by the time it discharges into the reservoirs at a manhole 150 feet off.

The Corporation works and destructor were next visited. In the engine house they were shown a pair of engines of 31 indicated horse-power, which compress the air into two large receivers, which, together with the 5-inch cast iron main, contained about 4000 cubic feet. It passes into the 5-inch main to the Town Quay, where it is automatically supplied to the ejectors when required, and it also drives the precipitated sludge through the main to the destructor. They also drive the dynamo for the electric light installation, there being no accumulators at present.

The party were then conducted to the destructor, that part of the works where the refuse from the town is deposited and burnt, and saw the whole process in operation, and the mixing of the sludge with the sorted town refuse and road sweepings, which then becomes a marketable commodity as manure. The road sweepings were never burnt, as they could always be sold. The furnaces and other parts of the works were also visited.

A series of questions, at the conclusion of the inspection, was put to the Surveyor (Mr. Bennett), who said they burnt nothing but garbage. Last year they realised £600 from the sale of manure. A good many farmers buy the contents of the ash bins in its original state. What was not sold was burnt. The clinkers from the furnace were stored and sold, and also made into paving slabs. Each furnace sometimes consumed 9 tons a day of twenty-four hours, and the six furnaces represented 54 tons a day. We have one feeder and two stokers.

Mr. Pildich said he had twelve stokers to twelve cells, working in three batches of four, eight hours each.

Mr. Bennett, further questioned, said the sludge was not dried, but mixed with road sweepings in dry weather, and in wet weather mixed with the ashes. The lowest quantity burnt was 25 tons and the highest 54. The sludge cell was capable of holding 20 tons of sludge. The sludge was from a population of 14,000, but the works dealt with the house refuse of a population of 60,000. He mentioned that the clinkers were utilised for road-making, concrete slabs, paving, and other purposes, and they were about to make a cinder track in Westwood Park, with the clinkers they now saw in the yard.

Mr. C. Jones: I feel very much gratified with all I have seen, The papers, as papers, have a great charm about them which we do not often meet with. They are very concise and clear. There is no doubt about the meaning of the words or the figures given. and instead of being complicated we can thoroughly understand them. Of town refuse and sewage disposal, I take it, we are the more interested in than the water question. We have seen the works, and therefore of necessity we must corroborate what we heard in the paper. As one who has taken some little interest in the subject of town refuse destruction, more particularly in the destruction of sewage sludge, and having done my best to improve it, and I thought I was pretty well at the top of the tree, but Mr. Bennett has gone further than I have gone. Probably he has had

the advantage of studying one or two—my own amongst them—and he has improved upon it. This is one of the great advantages we have in coming together. We carry the work of others home, and improve upon it, and keep on trimming the lamp as we go along. One great point is the economy with which these works are carried out. I do not know how they manage it at Southampton. I suppose the men are of a salamander class. I do not pity the men who were stoking, for they did not seem to require it. It is extraordinary that they can do the work they do, and do it so well. I know all the destructors in England, but not one where such a large amount of work is done as at the destructor at Southampton. There are those present who know as well as I do, and who will bear me out in saying—I do not seek to use smooth words, but the truth—there is no destructor in England, where a larger amount of work is got out of it than the one in Southampton, and I say all honour to Mr. Bennett, who has produced such admirable results. As to the development of the treatment of sewage with carbon, we are all pretty well tired of discussing it. However, in Southampton, you are treating sewage in an admirable way; and if it suits the views of those who have the control of these things, you are doing the best you can. The principle is that every tub in this matter should stand on its own bottom. As to the destructor, you have arrived at a very high standard, and I am going home to do likewise, for I have learnt something to-day. The President does not agree with me in the principle of destruction, but you have gone a little further than I have gone. Your treatment of tho refuse, the manufacture of stone, and the electric lighting, is a grand idea. The mode of utilising it for farm purposes is beyond all praise. I congratulate Mr. Bennett on the way the whole thing is carried out, and I hope he will continue to be prosperous, and that we may all go from here gathering useful lessons for the towns where we are engaged.

Mr. Eachus inquired as to the gradient of the pipe conveying the sewage to the outlet.

Mr. Cartwright: I havo come a long distance to see these works, and must express myself perfectly satisfied. I was one of the pioneers in the introduction of destructors, but, like Mr. Jones, I must see if I cannot improve ours. Our destructor is costing twice as much as yours in Southampton, and we are not utilising the heat to the same extent. We have learnt much to-day, and in the future I hope to improve our works at Bury. We have seen the concise manner in which the works are laid out

in Southampton, to which is owing the economical use of the destructor. I am pleased and instructed with my visit, and thank Mr. Bennett for the opportunity of coming here.

Mr. NORRINGTON: There is one feature in the paper I should like Mr. Bennett to some extent remedy. He has given us the particulars of how he deals with a certain portion of the sewage of Southampton. I think he might give us some little information as to how the remainder of the sewage of the town is dealt with. With reference to what we have seen to-day, it seems to me in many respects to be an improvement on what we have seen previously in other places. I am not at present absolutely convinced that the method of dealing with the refuse of towns by burning it wholesale is the best means of dealing with ashes and refuse; but so far as it has been done at Southampton it is certainly an improvement upon anything I have seen before. If the refuse is to be burnt, the utilisation of the heat is an important point to be borne in mind, and that question was to a certain extent solved in Southampton. We who have to deal with London refuse will also learn something from what we have seen to-day, although unfortunately we are unable to dispose of the sludge in the same way that Mr. Bennett does, as in all cases we have to pay a considerable price for carting it away, whereas you receive 2*s*. 6*d*. a ton for it. I congratulate Mr. Bennett and Mr. Matthews, not only upon their papers, but on the efficiency of the works they have carried out.

Mr. STRACHAN: The papers are very complete, but I should like to be informed upon one matter. Mr. Bennett put the whole of the concrete foundation—30 feet square, and 10 feet deep—continuously. What means did he take during the hours of darkness, to see that it was properly done? In such matters it is difficult to know whether to go on during the night; and I should like to know whether, under the means he adopted, it was perfectly satisfactory? Further, I should like to know in what respect the shaft was damaged by lightning, as every precaution appears to have been taken in the way of lightning conductors? Perhaps he will explain too, more clearly how it is that from one dynamo he can get sufficient current to feed ten arc lamps of 3000 c. p. each or 200 glow lamps of 16 c. p. each with the incandescent light. The discrepancy is more than is usually found in comparing the two lights. One of the most important matters in the paper is the question of lighting the town by hydocarbon oils and compressed

air. Much as we have been interested in all we have seen in Southampton to-day, if Mr. Bennett brings this matter to as great a perfection as he has his other works, Southampton will become famous in the history of lighting. When he has completed his experiments, perhaps he would favour the Association with a paper and put them as early as possible in possession of the information. One other point is, whether it is a fact Mr. Bennett gets one horse-power per hour out of 75 lbs. of refuse? The works were not absolutely built for the purpose of utilising the heat, it was an afterthought; and if he will give us the figures to confirm this, we would be glad to know this result was obtained upon a substantial basis.

The PRESIDENT: Mr. Jones has alluded to the fact that I am opposed to what he calls the destruction of the town refuse by so-called destructors. This is not quite a correct way of putting my opinions. I am opposed to the so-called destruction of town refuse, because in principle, it is injurious and wasteful, and although you have heard high praise passed upon the works you have seen, I do not know that my theory could have received more substantial support from any other works. The theory that municipal engineers should pay careful attention to, and the standard they should work up to, is that there should be little or no refuse to remove from houses. When you learn from Mr. Bennett that he has obtained a large amount of power from the refuse that has to be removed from dwellings, it shows what a waste is going on. First of all the householder has to burn coal in a most unsatisfactory, unscientific, and barbarous manner. It is only because fuel is so exceedingly cheap in England that open fireplaces are tolerated at all. Something like 90 per cent. of the effective value of the fuel is lost burning it in open grates. Except that you have the chimney to carry away the smoke it is only one step removed from the wood fire in the tent of the savage. With sanitary engineers this is a state of things that must not and will not continue for ever, and while the present necessity of town surveyors compels them to search about for practical means of getting rid of town refuse, the goal they should have in mind is the doing away with burning solid fuel in open fireplaces, and to bringing about a central factory for the production of heat and light. What would have been said 100 years ago at the idea of a central factory distributing light to every household in the town. Some of you here inwardly smile when I look forward to the rapid solving of the problem of the distribution of heat from a central station. This effected, of course in each house there would be no ashes to

remove, and the great bulk of the town refuse would have been abolished altogether. Then there would simply remain the decaying matter in the shape of vegetable and other refuse; there would be no difficulty whatever in designing a small stove for a large house that would absolutely burn all the refuse which now costs so much money to deal with. This may be an idea—an utopian idea—but still I throw it out because many municipal engineers have time and opportunity to work out a problem of this sort, and I hope the day is not far distant when some of you may have the skill and courage to carry it into practice. Mr. Strachan had alluded to a paragraph in the paper of the highest possible importance to municipalities and their engineers. That is Mr. Bennett's proposal to light the borough by heavy hydro-carbons. For the last eighteen months I have been managing director of a company whose business it is to manufacture and sell lamps burning heavy hydro-carbons, heavy oil of tar sold at 1½*d.* a gallon. This is a problem that is not going to be solved very easily. £50,000 has been expended, and chemists and engineers, have been attempting to solve the problem for the last 20 years. I have had the Patent Record searched, and find that there are 236 patents existing in reference to this subject. One man alone has invented 35 lamps. The subject lately has attracted a great deal of attention, and has grown with giant strides. Some of you were present the other day at our works and saw the lamp we were making. That lamp was superseded by one of another make, and we had to set our heads to work to supersede the lamp which had superseded ours. If Mr. Bennett contemplates dealing with the question, although ours is a commercial concern, I shall be pleased to let him come to our works at Westminster and reap the advantage of any experience we have gained, and give him the benefit of everything we have patented. It is a subject that will attract a good deal of attention, because heavy hydrocarbons are exceedingly cheap and can be obtained in any town where there are gas works, and any solution of this problem will be welcomed by the public at large.

Mr. Bennett, in reply to the questions, said:—The engines compress 4000 cubic feet of air into two receivers and the 5-in. cast iron air main, and when required for the transmission of the sludge which occupies about one hour per day, they are coupled, and work one air cylinder only. When the dampers were raised the fires immediately lighted up without any additional fuel. One engine uncoupled is sufficient for the electric installation. The Porous Carbon Company claim that the carbon supplied to us is rich in

iron and alumina. The time occupied in filling in the concrete foundation (333 cubic yards) was about seven days and nights; the light used was gas. The damage to the shaft consisted of the displacement of about eight courses of brickwork at the top of the cap, for about 15 feet round the circumference, since which a copper band, fused to the tape, has been placed all round the top of the cap, with two additional vertical rods, 5 feet and 4 feet 6 inches in height. We are experimenting in Southampton as regards hydro-carbon oil burning; we are continuing them now, and I am satisfied that we shall have beneficial results to the community. Many patents have been taken out, no doubt; I have taken several myself. In reply to Mr. Eachus, the main is nearly level and 18 inches below the surface. There is no gravitation, but the compressed air is used to force the sludge through it. As to the disposal of the refuse of the other parts of the borough, we dispose of the whole of it except from three or four thousand of the inhabitants of Portswood, who dispose of it by manuring their land, or otherwise. As to the electric lighting, I may explain that we are as yet in an experimental stage; but I have great faith in it, and from experiments we have carried out I do not see the slightest reason why we should not light any number of lamps from one given station. As regards the President's remarks about the waste of refuse, I am in sympathy with him there. I have frequently watched the loads coming into our yard, and I think the servants in our houses are guilty of great waste. I have seen pounds of good coal thrown into the destructor. If proper economy was exercised at home a great deal of it would never reach here. Still we have a large residue from the trade in the shape of wooden boxes, straw, paper, and sweepings of shops and business places, that alone would keep up steam sufficient for our work, and no doubt, as the town increases, we shall be able to keep that up still better, for, as I have already explained, 25 tons of refuse is sufficient for the purpose.

The President then proposed a cordial vote of thanks to Mr. Bennett and Mr. Matthews, for their papers and their kindness in taking them over the works, and both these gentlemen acknowledged the vote.

Mr. Lemon, proposed thanks to the President for the efficient way in which he had discharged his duties that day.

The President, in response, thanked, on behalf of the members, Mr. Lemon for his hospitality.

The members then left by special train for London.

THE SOUTHAMPTON WATERWORKS, 1290–1889.

By WILLIAM MATTHEWS, Mem. Inst. C.E., F.G.S.

The Waterworks of the town of Southampton have a history of more remote date than can be ascribed to almost any other such undertaking in this country, it being recorded that on June 16th, 1290 (Edward I.), one Nicholas de Shirlee granted to the Friars Minor the right to take water from a spring at Colwell to Archard's Bridge, and thence by the King's Highway to their Church in the town of Southampton; and it is further recorded that in 1310 (Edward II.), upon the Feast of the Purification, these Friars granted the use of the water to the Town. The old conduit head and water-house may yet be seen.

From this date until 1747, this and various other supplies from springs and wells, of a purely local character, were made use of.

In 1747 the first Act of Parliament was granted, and reservoirs (Nos. 1, 2, and 3) with earthen banks were constructed on the Common, in which surface water was collected and conveyed thence to the town in wooden pipes, some of which are still occasionally met with. Wells were also sunk near the town, and, with the above, served to supply the inhabitants until 1851. Reservoirs Nos. 2 and 3 are still used in connection with the supply for sanitary purposes; No. 1 has been demolished.

In 1838 the deep well and boring on the Common was commenced, and the work carried on intermittently until 1883, when it was abandoned at a depth of 1317 feet (842 feet in the chalk), having involved an expenditure of 20,000*l.*, and failed to yield the supply required. The shaft is lined with cylinders and brickwork to a depth of 467 feet, is unlined for a depth of 96 feet, and the remainder is bored and unlined.

In 1851 the Mansbridge works were initiated, and a supply of water from the River Itchen obtained; the works consisting of a brick-lined subsiding reservoir (3½ million gallons), a pair of Cornish beam engines, and four boilers; and at the same time the two brick-lined reservoirs (5 million gallons) at the top of the

Common were constructed. It is proposed to cover over these reservoirs (which are used in connection with the new supply) at an early date, at a cost of from 4500*l.* to 5000*l.*

In 1865, the capacity of the Mansbridge Works was increased by the erection of a new engine and boiler-house, a pair of rotative beam engines, and five boilers; and until lately these works have been in operation.

In August 1885, the Act for constructing the new works was obtained, and the Mansbridge works have been closed since February this year.

The new works consist of a pumping station and softening works, lime kilns, tramways, and cottages, erected upon a plot of land 13 acres in extent, to which access is gained by means of a newly-formed road and a siding from the Railway. A line of 24-inch pumping main, 1⅛ miles in length, leading up to a circular concrete and brickwork covered reservoir (one million gallons) on Otterbourne Hill, and a line of 16-inch gravitation main, 4½ miles in length, with brick subways under the railways, through which the water flows into the existing system of mains and the reservoirs at the top of the Common. The pumping station is 90 feet, the Otterbourne reservoir 250 feet, and the reservoirs on the Common, 200 feet above Ordnance Datum.

The pumping station is within 100 yards of the outcrop of the chalk, and the water is obtained from two bored wells (6 feet diameter) sunk 100 feet entirely in that formation by Messrs. Legrand and Sutcliff, of London, and from a length of 300 feet of headings, at a depth of 55 feet from the surface.

Pumping is effected by means of a pair of rotative compound receiver beam engines, one to each well, with two pumps to each engine; the one, a low-lift pump, raises the water from the well and delivers it through a 24-inch main, laid in a tunnel under the entire length of the buildings, to the softening works; the other, a high-lift pump, receives the water after it has been softened, and forces it up through a 24-inch main to the Otterbourne Hill reservoir. Each engine at its normal speed pumps two million gallons per day.

These engines are of the most approved construction and embody all the most modern improvements and details, thus rendering them extremely economical, a duty of over 125 millions being obtained at the guarantee trials. The cost of pumping is ·521 penny per 1000 gallons.

Steam is supplied by three steel Lancashire boilers, space being left for a fourth when required.

A repairing-shop adjoins the boiler-house, and contains lathes, drilling machines, and grindstone, besides a horizontal engine for working them and the machinery connected with the softening plant. The engines, pumps, boilers, tools, and machinery, were constructed and erected by Messrs. J. Simpson & Co., of London.

At the upper end of the range of buildings, the "hard" water from the well will be seen as it flows from the 24-inch main into an iron tank or "mixer," where it is softened by being mixed with lime water. Water from the chalk is "hard," owing to the presence in it of carbonate of lime in solution; thus rendering it invisible. If, however, lime water be added, the carbonate of lime is rendered insoluble (i. e. solid and visible), the water then appearing milky and turbid, and if this solid matter is allowed to subside or is removed, the water will become clear and be soft.

To carry out this process, chalk is dug in a quarry at the top of the field, and burnt in two kilns erected for that purpose, the resultant lime being conveyed in trucks to the mill-house, where it is "slacked" in two specially constructed mills, and the thick cream of lime produced is stored in a large brick-lined tank, to be used as required. An air compressor, fixed in the mill-house, forces jets of air through the lime to prevent it from settling, and a lime pump, fixed in the same place, pumps the cream of lime from the tank and delivers it into two large iron "lime cylinders," where, after admixture with water so as to make a completely saturated solution of lime water, it is ready for use. From these cylinders it flows by gravity through pipes and regulating valves into the "mixer," into which the hard water from the wells flows; there it is mixed, and, in a turbid and milky state, passes over the edge of a distributing weir and falls into a brick-lined tank of 100,000 gallons capacity, where some of the heavier part of the suspended matter now in the water is deposited. Passing over a weir wall, the water is then delivered to the filters, where the remainder of the suspended matter is removed, and the clear soft water falls into a brick-lined tank, and flows through two 36-inch pipes to the high-lift pumps.

The filtering is effected by passing the water through cotton cloth, mounted on perforated zinc on light hollow cast-iron discs, and so arranged that, to cleanse them, they are made to revolve, and jets of water at high pressure brought to bear upon their

surfaces. The softening plant, the largest ever erected, has been supplied by the Atkins Filter and Engineering Company, of London. The water is softened from 18 down to about 7 degrees of hardness and the cost is ·225 penny per 1000 gallons.

The cost of these works, with the Otterbourne Hill reservoir, and the pumping and gravitation mains, has been 63,000*l.*

Beyond this the Corporation have, during the past four years, in connection with the perfecting and reorganising of their waterworks undertaking, laid down about 14 miles of new mains within the borough, at a cost of 13,000*l.*; have adopted Deacon's waste water meter system, at a cost of 2600*l.*; and have initiated a new system for the supply of water for street watering and sanitary purposes from the old reservoirs (Nos. 2 and 3), and the deep well on the Common, at a cost of 450*l.* The old mains, which were inadequate to withstand a high pressure service, have been utilised for the distribution of this supply, while the pumping from the well is effected by means of a pair of hydraulic engines, driving a set of well pumps, and actuated by the water in the high pressure supply main without the loss of any water.

The effect of these works has been that, although the population supplied has during the past five years increased from 61,400 to 65,600, the working expenses have fallen from 5200*l.* to 4050*l.* per annum, and the receipts from water sold for trade purposes risen from 2200*l.* to 2650*l.*; and the consumption of water, which was at the rate of 60 gallons per head per day, has been reduced to 29 gallons, and is still falling.

DISCUSSION AND VISIT TO WORKS.

The PRESIDENT: We are all very much obliged to Mr. Matthews for his valuable paper. He has done that which is rarely done by anyone reading a paper—he has given us facts and figures derived from experience which will be invaluable for engineers. About two years ago I had to prepare a contract for large works in Egypt. I had a man searching the 'Proceedings' of the Civil Engineers for a fortnight to arrive at the cost, including coal, of lifting a ton of mud a foot high; but I could not ascertain that simple fact. When you get a paper giving figures ranging over a certain period, and obtained from actual experience, they are invaluable to practical engineers. The Corporation of Southampton, in softening their water, have adopted a principle it would be well that all

corporations should follow who obtain their water from the chalk formation. I may instance the case of the Corporation of Brighton. Their water was obtained from the chalk and was exceedingly hard. They derive a considerable revenue from their water supply, and instead of softening it, as has been done in this case, they have preferred to apply that revenue to the alleviation of the general district rate. That, I consider, is a very improper proceeding. When gas or water undertakings are acquired by a corporation, the first duty they owe to the consumer is to give them the best article at the lowest possible price, and not apply the surplus funds to purposes Parliament never intended. One is pleased to hear constantly that the system for the prevention of water waste designed by one of our past presidents, is bearing good fruit all over the country. We must congratulate Mr. Deacon that wherever a fair trial is given to his invention it always succeeds, and its success has never been more exemplified than in this paper, which shows that the consumption of water in Southampton has been reduced from 60 gallons per head to 29, and there is every likelihood of a still further decrease. We shall presently visit the waterworks, and it will be well that any further discussion should be postponed until then.

The Members were conveyed by special train to the new waterworks at Otterborne, a distance of eight miles from Southampton.

Here the softening process was first explained by Mr. Matthews, the water engineer, who said the chalk was dug near at hand and was brought in trucks to the kilns, and there burnt into lime and conveyed in trucks to the mill-house where it is slacked and the thick cream of lime produced stored in a tank to be used as required. There was a little pump for pumping up the lime, and also an air-compressor for pumping and forcing air through it to keep it from coming into a solid state. The cream of lime was pumped in small quantities into two cylinders where, after admixture with water so as to make a completely saturated solution of lime water, it was ready for use. It then flows by gravity through pipes and regulating valves into the mixer, where it is mixed with the water from the wells, and then passes into a tank of 100,000 gallons capacity where the heavier suspended matter was deposited. The tank was not so much for the purpose of storage, but to thoroughly mix the hard water with the lime so that the chemical action might be completed before passing into the filters.

Passing into another compartment the visitors were pointed out a row of tanks into which the water from the large tank passed by means of 6-inch pipes. Here the process of filtration is undergone, 2½ million gallons a day being treated, but provision is made for dealing with 3½ millions a day when necessary. The water flows into these small tanks in a milky state, and in each of the tanks is mounted a set of discs, which are composed of light cast-iron work covered with sheets of perforated zinc, either side of which is covered with a sheet of cotton cloth. The water percolates through the cotton cloth, and leaves on it a deposit of bicarbonate of lime, and acts in such a way that in course of time the cloth becomes choked. The great point was the means of cleansing the filters. When this becomes necessary the discs are made to revolve. There was a set of pipes in each filter connected with a high pressure service outside, and as the discs revolve, sprays of water were projected on the face of the cloth, and washed off the deposit, which falls to the bottom of the tanks and is taken away by drains to the outside. After a fortnight's work it was found the jets did not get rid of the whole of the deposit from the cloth. Some of it got hung up there. Originally a device was proposed for injecting high pressure water into the inside of the disc, and so blowing out the deposit from the pores; but it had a bad effect upon the cloth, as it opened the pores of it, and it had not sufficient elasticity to regain its former position. So now, instead of injecting water every ten days or fortnight, they inject live steam, by which means they got the cloths entirely freed and did not injure them in any way. They found in consequence of the action of the lime upon the cloths that they so deteriorated that renewal was necessary every six months, and in course of time they hoped to increase the life of the cloths to nine months.

The process of cleansing was then demonstrated in one of the filters. The members were there conducted through the repairing shop and the boiler-house to the engine-room, where Mr. Matthews gave a description of the engines by which all the pumping is done. He explained that the engines were of the most improved construction. They were a pair of rotative compound receiver beam engines, each working a low-lift pump raising the water from the well and delivering it to the softening works, and a high-lift pump sending the softened water to the Otterborne reservoir—being a lift of 220 feet, from thence a fall

of 50 feet to Southampton Common. The normal speed of each pump was two million gallons a day.

He also gave some information as to the geological situation, and explained that there were two wells sunk 100 feet in the chalk and 6 feet in diameter. In the first instance they were separate, but not acting in harmony a connection had to be made between them. The supply had been considerably increased by adits being thrown out. One important question in connection with the softening process was the means of disposing of the refuse from the filters. They had experienced some difficulty in the matter, but they hoped to overcome them. He was not aware that the problem had been solved anywhere.

Mr. Nichols (Southampton): Can't you make whitening out of it?

Mr. Matthews replied that from a chemical point of view it was pure whitening, but the difficulty was in getting rid of the crystallised condition which it assumed. They had been making experiments, but how far they would succeed remained to be seen.

The President said in his humble judgment these were the best waterworks he had had the pleasure of going over for some years past. They may not be so large as some of the great works they had visited in the north, but in completeness they were surpassed by none. Everything they had seen to-day had been engineering of a high-class character and reflected the greatest credit on the engineer who had carried them out, and they had the advantage of having them shown to them by an engineer who possessed the gift of giving lucid explanation of the works, and he could compliment Mr. Matthews on being an excellent showman.

LANCASHIRE AND CHESHIRE DISTRICT MEETING.

May 17, 1889.

INSPECTION OF THE MANCHESTER SHIP CANAL WORKS.

REPORT BY THE HON. DISTRICT SECRETARY, S. S. PLATT, ASSOC. M. INST. C.E., BOROUGH ENGINEER AND SURVEYOR, ROCHDALE.

BY the kind permission of the chief engineer, E. Leader Williams, Esq., M. Inst. C.E., the above works were thrown open for the inspection of the members of the Association, who assembled to the number of 100 at the Salford Docks. T. A. Walker, Esq., the contractor, generously placed a special train at the disposal of the members, whereby they were enabled to traverse the portion of the Canal Works extending from Salford to Latchford, near Warrington, a distance of fourteen miles, alighting at every point of interest on the route.

Before beginning a description of the works, it may not be out of place to briefly refer to the history of this gigantic undertaking.

The idea of a navigable waterway to Manchester engaged the attention of our forefathers about sixty years ago, but, being strenuously opposed, had to be abandoned.

In 1882, however, Mr. Daniel Adamson, C.E. and M.E., of Manchester, revived the question, and called his friends together at his house at Didsbury, when the final effort was inaugurated, which was also destined to be most strenuously opposed by the Railway Companies, and by the Liverpool Dock and Harbour Board.

Two schemes were under consideration; one by Mr. Hamilton Fulton, C.E., to make a tidal waterway from the estuary of the Mersey to Manchester, and the other by E. Leader Williams, C.E., for a waterway tidal to Warrington, but with an arrangement of locks between the estuary of the Mersey and Manchester. The

latter scheme was adopted, and submitted to Parliament in 1883, and passed the House of Commons, but was thrown out by the Select Committee of the House of Lords; afterwards, in 1884, it was passed by the Lords' Committee, but rejected by the Commons' Committee.

In 1885 an amended scheme was proposed, the canal to commence at Eastham, skirting the south side of the estuary as far as Runcorn, and then continue forward to Manchester pretty much on the lines as previously proposed. After much opposition this scheme received the assent of Parliament.

Then came the crucial stage of raising the necessary capital. Every obstacle was placed in the way by opponents; but, undismayed by temporary defeat, the promoters stuck to their project, and success seems now only to be awaiting them in the final stage of completion.

The first step towards the making of the Canal was taken on the 11th November, 1887, when Lord Egerton of Tatton, Chairman of the Directors, cut the first sod at Eastham; Sir Joseph Lee and other directors followed suit; the chief engineer, E. L. Williams, C.E., tipped the congregated soil from a barrow, and the whole business was over.

The work was put into the hands of T. A. Walker, Esq., of Westminster, the eminent contractor of Severn Tunnel fame, at the contract price of 5,750,000*l.*, to be completed by January 1892, with the stipulation that he is to receive or forfeit 100*l.* for every day under or over the allotted time, and he has spared no effort to push on the works with a determination which bids fair to be rewarded by the completion of the contract well within the stipulated period.

The length of the Canal from Eastham to Manchester is thirty-five miles, the minimum bottom width is 120 feet, and the depth 26 feet. It is wider than existing canals, as is shown in following table.

Canals.	Depth in feet.	Bottom width in ft.
Suez	26	72
Amsterdam	23	89
Manchester	26	120

There will be five sets of locks, viz. at Eastham, a group of three, one 600 feet long by 80 feet wide for ocean steamers, one 300 feet by 40 feet for smaller vessels, and one 100 feet by 20 feet for still smaller vessels; and one set each at Latchford, Irlam, Barton, and Mode Wheel, near Salford, consisting of two, one of 600 feet by 65 feet, and one of 350 feet by 45 feet; the total lift being about 60 feet.

The total estimated quantity of excavation is 47¼ million cubic yards, ⅛th of this being in rock. The total quantity of land required for the Canal Works is 3406 acres, but with the portions which the company have been obliged to purchase, by having access cut off from severed lands and other causes, the total will exceed 4000 acres; but there is no doubt that some of the surplus land having a frontage to the Canal will eventually prove remunerative to the company. The variety of interests and individual difficulties to be overcome may be imagined when it is understood that nearly 300 landlords and 350 tenants had to be dealt with before possession could be obtained of the land.

The completeness of the contractor's organisation is apparent, for the total length is divided into nine sections, each of which is complete in itself, having neatly-appointed offices erected on the works, all in telephonic communication with the head office and with each other, and to each section is accredited a resident engineer, assistants, and inspectors, on behalf of the company, and agents, sub-agents, engineers, assistants, cashiers, timekeepers, and gangers, for the contractor. Each section is provided with the necessary locomotive sheds, with steam hammers, and the requisite shops and tools for effecting repairs, water-tanks, coal stacks, stores, stables, and hospital for horses.

The total number of men and boys at the time of our visit was about 13,000, and the plant employed, which represents a value of 700,000*l.*, included 190 pumping and pile engines, 82 large steam navvies, about 5000 waggons, 158 locomotives, 205 horses, and 116 steam cranes.

For such large numbers of men, who have been suddenly brought into districts where no accommodation was to be found for them, the contractor has erected "navvy villages" of wooden construction, and he has been thoughtful of their spiritual and bodily welfare, in providing mission rooms, hospitals, surgeries, coffee taverns, penny banks, and shops.

For facility of transport of the necessary materials, the con-

tractor has laid a line of railway the whole length of the Canal (with the exception of a short piece near the Weaver mouth), which is dignified by the name of the "Overland Route," and with the tipping ways makes a total length of about 200 miles of line. The rails are steel, 56 lbs. to the yard, each spiked with four dogs to sleepers, 10 inches by 5 inches, 9 feet long; the waggons are side and end tip, each having a capacity of 4½ cubic yards, the side tippers being arranged to unload themselves when the pin is drawn, and right themselves afterwards.

The locomotives are principally made by Manning, Wardle, & Co., Leeds; Hunslet Engine Co., Leeds; and Hudswell, Clarke, & Co., Leeds.

The excavating plant includes (1) a good number of Ruston, Proctor, & Co.'s steam navvies, (Dunbar & Ruston's patent); (2) crane excavators by Whittaker Brothers, Horsforth, Leeds; (3) J. H. Wilson & Co., Liverpool; (4) J. Smith, Rodley; (5) grabs by Priestman Brothers, Hull; (6) land dredgers by the Lübecker Machinenbau Gesellschaft, Lubeck (known as the German excavator); and (7) Buette's machine (land dredger) made by Boulet, of Paris (known as the French excavator).

The steam pile-drivers are by Sissons & White, Hull; and Lacours and De Witt.

The pumps are of all varieties, centrifugal, pulsometer, bucket worked by beam engine (two of these latter 31-inch diameter, from the Severn Tunnel Works), and others, by well-known makers.

The portable engines are also by the well-known firms of Ransomes, Sims, and Jeffries, of Ipswich, and Ruston, Proctor, & Co., of Lincoln.

The steam cranes are by T. Smith, Rodley; Priestman Bros., Hull; Wilson & Co., Liverpool; and Pearson & Knowles, Warrington.

For a full description of the excavating machines above mentioned, reference should be made in regard to

(1) to 'Engineer,' 21 Sept., 1888, p. 242; for illustrated description, 'Contract Journal,' 17 July, 1889, pp. 77, 78.

(2) to 'Engineer' 21 Sept., 1888, p. 242; for illustrated description, 'Contract Journal,' 17 July, 1889, p. 77.

(3) to 'Engineering,' June 8, 1888, p. 570; for illustrated description, 'Contract Journal,' 12th and 19th July, 1889, pp. 748, 780.

(6) 'Engineer,' 21 Sept., 1888, p. 242; 'Engineering,' June 29, 1888, p. 649; for illustrated description, 'Contract Journal,' 26 June, 1889, pp. 817, 818.

(7) 'Engineer,' 21 Sept., 1888, p. 242; for illustrated description, 'Contract Journal,' 26 June, 1889, p. 817.

Good records of the work of Ruston and Proctor's steam navvy give, with a small bucket (1½ cubic yard capacity), during three consecutive days of ten hours each, 385, 356, and 354 waggons, holding 4½ cubic yards each; with the larger buckets of 2¼ cubic yards capacity, in same time, 423, 360, and 440 waggons, the excavation being in sandy clay with a face of 22 feet.

A bonus is paid to the workmen at each excavator, so much per waggon when the number exceeds a fixed quantity.

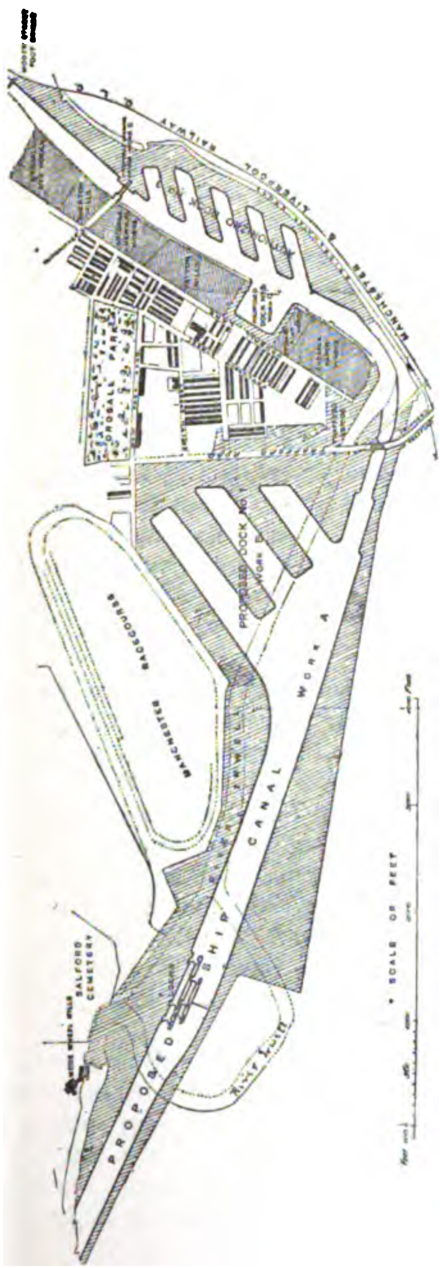
On four consecutive days of ten hours each, the work of (6) the German excavator was 714, 736, 721, 732 waggons, and on one occasion the number was 765; of (7) the French excavator averaged about 600 waggons per day of 9½ hours, the greatest number being 713. Both of these machines are however only fitted for soft material, the (1) Ruston & Proctor's being more generally serviceable for varying strata.

For a list of the plant referred to, and their sizes, see 'Engineering,' p. 325, October 5th, 1888.

On some sections the work has been proceeded with day and night, the illuminant at night being the "Wells" light, which is somewhat similar to the "Lucigen" light, having a small hand compressor, which must be attended to occasionally. The pressure when renewed is 20 lbs. to the square inch, which gradually falls to 5 lbs., when it must be again raised. The light is obtained by driving the vaporised oil through the small orifice in the ignition tube, giving a flame of about 2000 candle-power, produced from a cheap petroleum at a cost of 3*d.* per hour.

The inspection commenced at Salford Docks. These will have a water space of 114½ acres, quay space of 152 acres, and quay frontage of 9000 lineal yards. The work of building the dock wall had been well pushed forward, to effect which trenches had been cut round the side of the docks, in which the walls of concrete had been built before excavating for the dock proper. The total amount of excavation at these docks is about 5½ million cubic yards. The height of the walls is 34 feet, the coping level being 8 feet above the intended water level.

The walls are 17 feet thick at foundation, and 10 feet 6 inches at top, the face battering 1 in 16. The concrete is composed as follows: for the foundations, six measures of gravel, two measures of sand, and one measure of Portland cement; for the walls, five of gravel, two of sand, and one of cement; for the facing concrete, two of gravel, two of sand, and one of cement. About 700 tons of



PLAN OF SALFORD AND MANCHESTER DOCKS.
(From 'Contract Journal.')

cement are used per week at this work. The concrete walling is built by an arrangement of wooden shutters, which are worked in slides arranged against the dock side of the trench, about 9 feet apart centres; at the commencement the shutter is let down to the bottom, and the concrete filled up to top of shutter, when, after setting three to four days, it is sufficiently hard to allow of the shutter being wound up for another course of concrete, about a yard each time, until the coping level is attained, which takes about a month. Granite fenders are introduced a little above water-level, and a granite coping, 4 feet wide by 2 feet thick, completes to level of quay. Most of the concrete is mixed by hand, and sent down the trenches in shoots fixed in alternate bays of the timber settings. There are a few concrete-mixing machines employed (Carey and Latham's patent), each estimated to turn out 20 cubic yards per hour. It is intended to provide 50 hydraulic cranes on the quays of these docks, with lifting powers from 1½ to 20 tons.

For the first 14 miles of its course from Manchester, the work of making the Canal practically resolves itself into a straightening and deepening of the course of the river Irwell. From the Salford Docks near Manchester to Barton, a distance of about 4 miles, the bottom width will be 170 feet; below Barton locks, the bottom width will be 120 feet.

The side slopes of the canal vary according to the character of the strata, and, except where the cutting is in rock, will be pitched with sandstone (obtained on the works), with a strong toe at foot. Where the strata is rock, the side slopes will be 1 in 6 to water level, and 1 to 1 above to top bank level; in ordinary ground the slopes will be 1 to 1 throughout; in soft ground 1½ to 1; and in soft wet ground 1½ to 1 to water level, and 2 to 1 above. (For type sections see 'Engineering,' 7th October, 1887.)

The bottom of the Canal, throughout its entire length, is below the drainage of the country it traverses, so that in many places where drainages are cut, syphons will have to be provided to bring them under the Canal.

At Barton Aqueduct arrangements will have to be made for the carrying of the Bridgewater Canal over the Ship Canal. It is proposed to effect this by means of a swing opening trough or caisson of about 90 feet in width and 27 feet in height from water level to water level. Here also, parallel to the Aqueduct, will be constructed hydraulic lifts, to raise and lower barges between the

two navigations.* The new Aqueduct will have to be completed on the upper side of the old one, before the latter can be removed.† Just below the Aqueduct is Barton Bridge, which will have to be replaced by a swing bridge. Below this, again, will be the Barton Locks; between these and the Irlam Locks, a distance of about 3 miles, the canal cuts through the river several times in its zigzag course.

Between the Barton and Irlam Locks, the special train was brought to a standstill, and the members were entertained to an excellent *al fresco* luncheon, generously provided by the contractor. At this stage the opportunity was taken to transact the formal business of reading and confirming the minutes of the previous District Meeting, and the re-election of the Hon. District Secretary. The President then proposed, in felicitous terms, the hearty thanks of the Association to the Chief Engineer, E. Leader Williams, Esq., M. Inst. C.E., for the facilities afforded of inspection of the works, and to the Contractor, T. A. Walker, Esq., for the great kindness extended to the Association in so generously providing special means of transport along the works, and for the excellent luncheon which the members had partaken of. This was seconded and cordially taken up by the members present. Mr. L. P. Nott, son-in-law of Mr. Walker, and agent for Sections Nos. 8 and 9, Salford and Barton, who had accompanied the members up to this point, and explained the matters of interest, responded on behalf of Mr. Walker.

About a quarter of a mile below the Irlam Locks, the first railway deviation occurs, which will necessitate a considerable length of new bank, 60 feet high, and a viaduct for four lines of way, to carry the Cheshire lines (Manchester and Liverpool Railway) across the canal between Irlam and Flixton. The viaduct will be built at a height to give 75 feet clear headway above the canal, the ruling gradient of the line being 1 in 135. The bank was about half constructed at the time of our visit. Just below this deviation, arrangements are being made for a lay-bye for the Manchester Corporation Health Depot. A little lower, at Partington, arrangements will have to be made for a coal basin and tips, with branch lines to the Glazebrook and Stockport branch of the

* Similar to the Anderton Lift on the Weaver navigation, described and illustrated in 'Proceedings Inst. C.E.,' vol. xlv. p. 107, &c.

† For description and illustration of Brindley's Aqueduct, see Smiles' 'Lives of the Engineers,' vol. i. pp. 172–175.

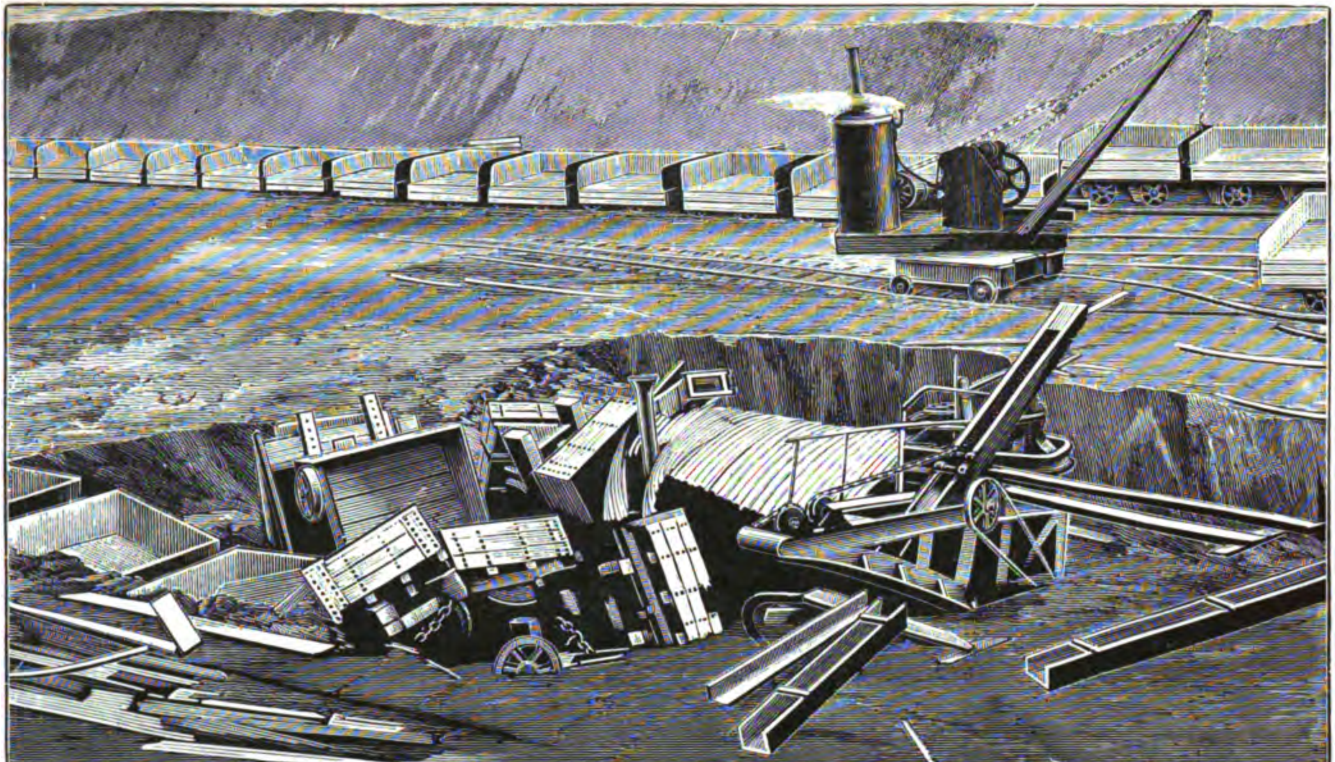
Cheshire Lines Railway, which will also necessitate a second railway deviation, similar to last described. There will be five railway deviations made. About two miles lower down, and ten miles from the Salford Docks, the Canal crosses the road at Warburton, where a swing bridge of 120 feet span will be erected to accommodate the road traffic.

Wherever roads are cut by the Canal and the importance of the traffic on them does not warrant swing bridges, ferries will be provided. All swing bridges will be worked by hydraulic power.

Just below this, again, at the time of our visit, attention was drawn to a landslip, of some 20,000 cubic yards of soft stuff which had slipped in the night from the southern slope, and flowed right and left into the cutting, burying in its course a Ruston and Proctor's steam navvy, and a number of waggons. Near here also several excellent geological sections were exposed by the cutting, the strata being the red and grey Keuper shales, which were faulted and contorted in various directions; and here and there the beds were interspersed with layers of gypsum.*

At Thelwall the river has been diverted into a new cutting, 600 yards long, with a bottom width of 100 feet and a depth of 20 feet, which is crossed by a neat suspension foot-bridge, 214 feet total span, centre span being 100 feet. The present ferry across the river will be transferred to the new Canal. The excavation and banking for this diversion were carried out by means of horse and steam barrow roads, a repetition of which was seen in other sections of the work. The barrows are filled by men in the cutting, and one man is kept continually going up and down each set of planks; these planks are inclined at an angle of 45°, and from the top of the bank to the bottom of the cutting measures about 40 feet. The barrow and man are raised up the incline by means of a rope drawn by a horse at the top, for the man could not walk up without having hold of the barrow, and when the barrow has arrived at the top the rope is loosed and the man slides down the incline with an empty barrow behind him; by this means about 100 barrows an hour are taken up and down each plank. There were six of these horse roads and two steam barrow roads at this work. Each of the steam barrow roads took up eight barrows at a time, on a platform on which they are placed,

* A series of geological sections, taken at the Salford Docks and also along the centre of the line of Canal, about a mile apart, are to be found in 'Engineering,' 17 Sept. and 7 Oct. 1887, pp. 300–306, 374–377, 384.



LANDSLIP AT WARBURTON—WAGGONS AND STEAM NAVVY BROKEN AND BURIED BY DEBRIS.
(*From 'Ship Canal News.'*)

[*To face p. 64.*

the average being 125 barrows an hour. (For illustration of this, see 'Graphic,' 25th August, 1888, p. 217.)

Near here the contractor has erected a brick-making plant, capable of turning out a quarter of a million bricks per week, excellent clay being obtained in the cuttings near; the bricks being used for the piers of the viaducts of the railway deviations.

Below this is the site of the Latchford Locks, the last but one, the other being at Eastham, near the entrance from the estuary. Between these two locks the Canal is tidal.

Below the site of the Latchford Locks is the third railway deviation, on the Warrington and Stockport line (London and North-Western Railway), the viaduct and bank of which will be similar to those previously described. A new station will have to be built at Latchford.

Here the inspection of the Members of the Association ended. Train was taken here to Lymm, where the members dined together, the President, E. B. Ellice-Clark, in the chair.

The above report is the result of observations taken by the author before and since the visit of the Association; but he also desires to express his obligations to the publishers of 'Engineering,' the 'Contract Journal,' and other periodicals, for many details contained herein.

DISTRICT MEETING AT HULL.

June 22nd, 1889.

Held at the Town Hall.

JOSEPH GORDON, *Past-President, in the Chair.*

The Mayor of Hull (Dr. Sherburn) opened the proceedings by very cordially welcoming the Association to the town; and entertained the company to luncheon. Visits to various works followed, after which the members returned to the Town Hall, where the following paper was read and discussed.

MUNICIPAL ENGINEERING IN HULL.

BY A. E. WHITE, ASSOC. M. INST. C.E., BOROUGH ENGINEER, HULL.

As this is the first occasion upon which the Association of Municipal and Sanitary Engineers have visited Hull, the following general particulars of the borough may be of service.

The estimated population is 208,000, rateable value 700,000*l.*, and land area, since the extension of the boundary in 1883, 7901 acres. Previous to the extension the population was 154,000, rateable value 587,000*l.*, and area 3621 acres.

The entire borough is very flat and low-lying, and the average level of the streets, which are almost without exception somewhat above the natural surface level, is only about 9 feet above Ordnance datum, and as a rule the ground nearer the Humber is higher than that farther inland. The sub-soil consists of a stiff yellow clay to an average depth of about 6 feet, below which are strata of silt varying more or less in character, also in most places a thin stratum of peat and often a quantity of running sand. Boulder clay is met with at depths varying from 14 feet to 35 feet or more in different

parts of the borough. The upper clay forms a good foundation for ordinary buildings, but for structures of a heavier character it is usually necessary to go to the boulder clay.

The borough is divided, by the river Hull and a line of docks, into three districts—(1) the Old Town, which was the portion formerly fortified, bounded on the south by the Humber, on the east by the River Hull, and on the north and west by docks, which portion contains a population of about 12,000; (2) the West District, west of the River Hull and of the line of docks referred to, containing a population of about 152,000; (3) the East District, east of the River Hull, containing a population of about 44,000. The borough is further severed by five large open agricultural drains, flowing to the River Hull or the Humber, from extensive low-lying districts north of the town.

The works herein described were in all cases, except where otherwise mentioned, designed by and carried out under the supervision of the Borough Engineer for the time being, and his staff; and for the purpose of indicating the position of the Author with respect to such works it may be explained that from 1878 to 1884, he occupied the post of Chief Engineering Assistant, and from 1884 to 1886 the post of Assistant Borough Engineer, under his able predecessor, Mr. J. Fox Sharp, M. Inst. C.E., and after Mr. Sharp's resignation, in 1886, was appointed Borough Engineer.

Sewerage.

From the foregoing particulars it will be gathered that considerable difficulties have to be contented with in the sewerage of Hull. The average level of the streets, as stated, is about 9 feet above Ordnance datum, while in the Humber, to which the sewage flows, the level of high water of ordinary spring tides is 12·37 feet above Ordnance datum, and the level of low water of ordinary spring tides 10·10 feet below Ordnance datum; and under such conditions the inclinations of the main sewers are necessarily very flat, and the outfalls, where pumping is not adopted, are of course closed for a considerable period each tide. As a rule the sewers are at least of sufficient size to enable men to enter for the purpose of brushing them out, where the inclination and flow of sewage are insufficient to render them self-cleansing; and their large size assists in a rapid discharge during the short periods that the out-

falls are not tide-locked; and also enables the sewers, when the outfalls are closed, to act as a reservoir, if pumping is not available, or if the quantity of water during excessively heavy rains is more than the pumps for the time being can deal with.

A main sewerage system for the East District was carried out in 1854 and subsequent years, and for the West District in 1863 and subsequent years. Considerable additions have since been made, from time to time, to such systems. During the past ten years the Corporation have expended the sum of 40,000*l.* upon new sewers, which have been constructed under various contracts, exclusive of sewers included in the works specially mentioned herein, and of works of minor importance executed by the Corporation workmen; and the Corporation are now applying to the Local Government Board for sanction to borrow a sum of 7950*l.* for the construction of further works of sewerage.

The whole of the West District within the old borough boundary is drained to one outfall, excepting a small area which, although connected to the main sewerage system, has also a separate outfall. The main outfall sewer, which discharges into the Humber between the William Wright Dock and St. Andrew's Dock, is 6 feet 6 inches diameter for a distance of 1900 yards, and although laid to an inclination of only 1 in 3000 it keeps itself clear of any deposit of sewage matter. The area added to the borough on the west side in 1883, which included the Local Board District of Newington and a part of the Local Board District of Cottingham, is drained to an outfall 4 feet in diameter, discharging into the Humber within 33 yards of the main West District outfall; and since the borough extension, a pumping station, hereinafter described, has been established to deal with the sewage of the main West District sewer and the Newington and Cottingham sewer, including the sewage of the portion of the Cottingham District not added to the borough.

The present sewerage system of the East District, with the exception of a short length of sewer, all falls to one point, and discharges into the Humber by an outfall 4 feet in diameter; a new system of sewers, however, which is usually described as the East District and Stoneferry Drainage, is now in course of construction, and will, when completed and connected to the existing system, not only drain portions of the borough which cannot be drained by gravitation to the present sewers, but will also provide an improved outfall for the entire district.

The Corporation have been authorised to borrow the sum of 39,000*l.* for the East District and Stoneferry Drainage. Of this sum 20,000*l.* has already been expended, and the works unexecuted are now proceeding under four separate contracts. The new outfall will be to the east of the Alexandra Dock of the Hull and Barnsley Railway Company, in the face of a river embankment constructed by the Company a few years since; and its level will be 10 feet below Ordnance datum, or practically the same level as the three existing outfalls already mentioned. The outfall sewer is 6 feet 6 inches diameter, with an inclination of 1 in 3000 for a distance of 700 yards from the Humber, and almost the whole of such length (being through made ground, or through what was until recently the foreshore of the Humber) is intended to be constructed of cast-iron pipes supported upon piles, as shown by lithograph, p. 82. The pipes are flanged and jointed in the manner shown by enlarged detail. A strip is cast upon the face of each flange at the outer edge, so that a space of three-eighths of an inch is left between each pair of flanges when bolted together, and such space is calked from the inside with iron cement. In laying the iron pipes considerable difficulties have been encountered, in consequence of the nature of the ground and of the water finding its way into the trench each tide; about half the intended length of pipe has, however, now been successfully laid.

The remainder of the sewers, excepting two syphons under agricultural drains, are all of brickwork, varying in size from 6 feet diameter to 3 feet 3 inches by 2 feet 2 inches, egg-shaped, with inclinations varying fron 1 in 3000 to 1 in 450. The length of sewer from the outfall to the most distant point is 4 miles, and the total length, including branch sewers, 6 miles, of which about 4 miles have now been constructed. The brick sewers, 6 feet 6 inches diameter, and 6 feet diameter, are in 14-inch work. Those 5 feet diameter and the egg-shaped sewers, from 5 feet 6 inches by 3 feet 8 inches, down to 3 feet 6 inches by 2 feet 4 inches, were all intended to have been in 9-inch work, but in constructing some lengths of the larger sizes through bad ground it has been found necessary to use an additional half-brick ring on the invert. The sewers of the smallest size, 3 feet 3 inches by 2 feet 2 inches, are in 4½-inch work. Cradling composed of 1-inch deal boards on elm ribs, as shown by sections of 6-feet brick sewer, has been largely used under some of the deeper sewers; and in the case of these works, as well as in previous works in the borough, such cradling has been

found a cheap and efficient means of supporting the brickwork, where the nature of the ground has rendered some support necessary. One tidal gate is provided at the outfall, and a penstock and two further tidal gates 670 yards from the outfall, where it is intended ultimately to erect a pumping station. Manholes, with ventilating gratings, are constructed at intervals of 100 yards, and provision for flushing the main sewer will be made near the highest point.

The 6 feet 6 inch iron pipes are being supplied under a contract with the Stanton Ironworks Company, Nottingham; and the laying of such pipes, and the construction of the brick sewers are being, or have been, executed by the following four firms of local contractors, viz.:—The Executors of Joseph Pearson, Mr. T. B. Mather, Messrs. Simpson and Malone, and Messrs. Turner and Sangwin.

Street Works.

Most of the streets in Hull are macadamised, including some of the main roads which, so far as economy is concerned, it would be more advantageous to pave. A number of the less important streets in the older portions of the town are paved with cobbles; about 12 miles of streets are paved with granite setts; and there are about 11,000 square yards of wood pavement in the borough. Portions of the cobble pavement and macadam are being replaced, from time to time, with granite or wood, and during the past ten years the Corporation have expended the sum of 60,000*l.* upon street paving works executed under various contracts, in addition to work carried out by their own workmen; and they are now applying to the Local Government Board for sanction to borrow a sum of 28,700*l.* for paving.

The Granite Pavement recently laid is formed chiefly of Aberdeen granite setts 3½ inches by 6 inches. The foundation consists of 7 inches of cement concrete, 8 to 1, on which the setts are bedded in fine gravel or sand and cement, mixed in the proportion of 5 to 1, and the joints are racked with fine shingle and run with asphalte. The present cost of this pavement is about 10*s.* per square yard, but in some cases a smaller sett is used, at a somewhat lower price. Until recently it was the practice to use lias lime concrete, 6 to 1, for the foundation, and to bed the setts on gravel, but the present mode of executing the work is found to be more satisfactory, and the

extra cost is small in a town like Hull, where Portland cement is manufactured, and where lime is subject to a heavy carriage. The paved streets are formed with a camber of from 1 in 30 to 1 in 36 (according to width) from the average level of the channel to the crown, and are usually channelled with 8-inch by 6-inch granite, and curbed with 6-inch by 12-inch granite edge curb, on concrete foundation. The footways are flagged with 3-inch Yorkshire tooled flags, with a fall of from 1 in 26 to 1 in 30.

The Wood Pavement most recently laid is formed of redwood blocks, 3 inch by 9 inch by 5 inch, creosoted with 12 lbs. to the cubic foot. The foundation consists of 7 inches of cement concrete, 6 to 1, faced with ½-inch cement and sand, 3 to 1, worked to a smooth and regular surface, upon which the blocks are laid without any bedding material. Spaces of three-eighths of an inch are maintained between the courses by laths ⅜ inch by ¾ inch laid on the foundation, which spaces are racked with fine shingle and run with asphalte to within 1 inch of the surface and the remainder of the joint is run up with cement grout, mixed in the proportion of 1 of cement to 2 of sand. The cost of the last wood pavement executed in this manner, viz. that laid in St. John Street towards the end of 1888, was 11*s.* 3*d.* per yard, but similar pavement was laid at 8*s.* 6*d.* per yard in 1887, when wood was cheaper.

In 1886, Albion Street was paved partly with creosoted and partly with uncreosoted blocks, the best blocks being picked out and laid without creosoting, and up the present time there is no apparent difference in the wear of the creosoted and uncreosoted portions. The earliest wood pavement put down in Hull was of beech and elm, laid in 1875. Numbers of the blocks in this pavement decayed before wearing out, and the whole has now been renewed with redwood, excepting portions of Whitefriargate and Silver Street, which streets are to be repaved during the present summer.

For the purpose of determining to what extent, so far as cost is concerned, it is desirable in this borough to substitute granite or wood pavement for existing macadam, and of assisting in deciding between the respective merits of granite and wood, the author has prepared estimates of the annual cost per square yard of maintaining the three descriptions of material, including interest upon first cost in the case of granite and wood.

Assuming that the pavement is carrying a traffic such as would necessitate a road macadamised with whinstone being hacked up

and coated twice per annum, the following are the works estimated for in the case of granite, viz:—

			s. d.	
First cost		.. ..	10 0	per yard.
In 11 years		relay half the area at 1s. 9d.	0 10½	„
„ 22	„	redress and relay half the area at 3s. 9d.	1 10½	„
„ 33	„	relay half the area at 1s. 9d.	0 10½	„
„ 44	„	redress and relay half the area at 3s. 9d.	1 10½	„
„ 55	„	relay half the area at 1s. 9d.	0 10½	„
„ 65	„	redress and relay half the area at 3s. 9d.	1 10½	„
„ 75	„	renew the whole, and thereafter maintain as before.		

The sum of 3s. 6d. per yard is sufficient to produce, at 3½ per cent. compound interest, the amounts required for maintaining and renewing as above, exclusive only of the first cost,

Assuming the traffic to be as before stated, the following are the works estimated for in the case of wood pavement, viz:—

	s. d.	
First cost	10 0	per yard.
Maintenance, taken as equal to renewing on old foundation every 10 years at	7 0	„

In addition to the first cost, the capital amount required to produce 7s. every ten years at 3½ per cent. compound interest is 17s.

The following are the estimates of the annual cost per yard of the three descriptions of material—granite, wood, and macadam—based on the foregoing figures:—

GRANITE.

	d.
Interest on first cost, 10s. at 3½ per cent.	4¼
Amount to provide for maintenance, 3s. 6d. at 3½ per cent. ..	1½
Annual cost per yard	5¾

WOOD.

Interest on first cost, 10s. at 3½ per cent.	4¼
Amount to provide for maintenance, 17s. at 3½ per cent. ..	7
Annual cost per yard	11¼

MACADAM.

Twice coating (including hacking up, stone at 9s. 6d. per ton at station, binding material, watering, and rolling), per yard	10

Corresponding estimates for the three materials under a traffic such as would necessitate a coating of macadam once per annum are as follows:—

GRANITE.

	d.
Interest on first cost, 10*s.* at 3½ per cent.	4¼
Maintenance	¾
Annual cost per yard	5

WOOD.

	d.
Interest on first cost, 10*s.* at 3½ per cent.	4¼
Maintenance	3½
Annual cost per yard	7¾

MACADAM.

	d.
One coating, per yard	5

If scavenging were taken into consideration it would make the foregoing estimates considerably more unfavourable to macadam.

NEW STREETS laid out for building purposes in this borough are constructed to a width of 40 feet, with footways 8 feet wide. The carriageway is formed of—(1) a foundation of hard chalk stone, or other suitable material, 8 inches thick, broken to sizes not exceeding a 4-inch cube and properly rolled; (2) a 2½-inch coating of granite, or other similar stone, broken to pass through a 2¼-inch ring, rolled and set with a proper quantity of binding material; and (3) a 2½-inch coating of whinstone, broken, rolled, and set in a similar manner to the previous coat, and finished with a camber of 1 in 24 from the average level of the channel to the crown. The last coating of macadam is usually omitted until the greater portion of the street is built up. The channelling consists of self-faced Yorkshire stone, 10 inches by 6 inches, laid in gravel on chalk foundation, and the footways are curbed with 5-inch by 12-inch tooled Yorkshire stone, also laid in gravel on chalk foundation, and flagged with 3-inch tooled flags. New streets, when completed in this way (the top coating of macadam excepted), are taken over by the Corporation and declared public highways under the 146th section of the Public Health Act, upon the owners paying the estimated cost of the coating of macadam and of maintaining the street for 12 months.

In consequence of the practice of taking over new streets as soon as constructed, the number of PRIVATE IMPROVEMENT WORKS in the old portion of the borough has of late years been comparatively small; but a number of streets have recently been made, or are now

in hand as Private Improvements Works, in the areas added to the borough in 1883. Such streets are constructed in a manner similar to that described for new streets, unless there be some special reason for using sett pavement for the carriageways, and are taken over as public highways when completed.

Ferry Boat Dock and Victoria Pier Improvement.

This improvement was carried out in 1881 and 1882. The best mode of dealing with the dock and pier was a matter which had been discussed for many years, and plans for a number of schemes, much more elaborate and costly than that finally adopted, had at various times been submitted to the Corporation. The principal features of the scheme carried out were the widening of Nelson Street (which runs parallel with the outer portion of the pier), by the construction of a new river wall about 200 yards in length, and the filling in of a portion of the dock; the improvement and partial re-construction of the Victoria Pier; the construction of a raised promenade over a portion of the pier and a portion of Nelson Street; the diversion of the main outfall sewer of the Old Town, by the construction of about 400 yards of new brick sewers; and the paving of Nelson Street.

The river wall consists of a bank of chalk-stone rubble; faced with timber piling and planking, tied in to back piles by iron tie-rods. The greater portion of the Victoria Pier was removed and replaced by new work, including the whole of the upper timbers, and the decking was renewed in 7-inch by 4-inch calked planking. The raised promenade is carried by 76 cast-iron columns, and decked, in a similar manner to the pier, with calked planking, resting upon timber joists and girders; and is approached by two flights of steps from Nelson Street.

The contract plans for the work, 14 in number, were photolithographed, and copies supplied, together with copies of the specification and quantities, to the contractors who proposed to tender. The whole of the works, except the paving, were carried out by Messrs. Storry and Jagger, Hull, and the cost, including paving, was 19,600*l*.

Refuse Destructor.

In 1882, the Corporation erected a Fryer's Refuse Destructor, with six cells, at a cost of 3100*l*., including the necessary building

adjoining and over the cells, and a chimney 180 feet high, but exclusive of the value of the site. There is nothing calling for special remark in the construction or working of the destructor.

SEWAGE PUMPING STATION.

As already stated, a sewage pumping station has been provided for the West District of the borough, dealing with the sewage of the main West District sewer and the Newington and Cottingham sewer. Such pumping station is about 370 yards from the outfalls into the Humber, and from the site plan on the lithograph, p. 82, may be seen its position with reference to the sewers named, also the lines of the new sewers which have been constructed, leading to and from the pumping station.

At low tide, the sewage flows to the Humber by gravitation as before, and when pumping is necessary the sewage is still discharged by one or both of the old outfalls. Two tidal gates and a penstock have been fixed on each of the old sewers, between the points of connection of the sewer leading to the station and the return sewer from the pumps; and while pumping is proceeding the tidal gates are of course closed, and the length of sewer outside them is under pressure, varying with the rise and fall of the tide in the Humber. When the tide is low enough to allow of a discharge by gravitation, the tidal gates are open, permitting the sewage to flow direct to the Humber without passing the pumping station.

There are three compound pumping engines of the vertical, inverted, direct-acting type; each capable of discharging 10,000 gallons per minute, or 14,400,000 gallons per 24 hours, when working at the maximum speed of 20 revolutions per minute. The cylinders are 18 inches and 30 inches diameter respectively, with 4 feet stroke, and the high-pressure cylinders are fitted with variable expansion gear. Each engine works two double-acting pumps, 30 inches diameter and 4 feet stroke, one pump being placed beneath each cylinder. The maximum lift is 20 feet; but as the pumps have only to work against whatever head of water there may be in the Humber, the lift varies with the state of the tide. A surface condenser is fixed on the delivery pipe from each pair of pumps, so that the whole of the sewage pumped is passed through the condenser.

The boilers are of the Cornish type, four in number, each 26 feet long and 6 feet diameter, with 3 feet flue. Steam is supplied at a

pressure of 80 lbs., and each boiler is capable of working one engine. A Green's Economiser, for heating the feed-water, is fixed on the line of the flue, between the boilers and the chimney.

The form of the buildings will be seen from the lithograph, p. 82. The foundations of the pump chamber are carried into the boulder clay to a depth of 32 feet below the ground-level, and formed of cement concrete 6 to 1. The walls of the chamber are of brick-work in cement up to the level of the engine-house floor, and are supported against the lateral pressure of the earth by a heavy framework of cast-iron girders and struts, fixed at a level about midway between the base of the wall and the surface of the ground. The buildings are faced with white stock bricks, with Pately Bridge stone dressings.

A tell-tale, designed by the author and manufactured by Messrs. W. H. Bailey and Co., Salford, is placed in the engine-house. Such tell-tale is worked by gearing and spindles from the engines, and by floats and platinum wires from the sump and delivery well, and shows at a glance the level of the sewage in the sump, which is the same as that in the adjoining sewers; the level of the sewage in the delivery well, which practically corresponds with that of the Humber; and also the head against which the pumps are working. The tell-tale, further, antomatically records the above levels on a roll of paper driven by a clock throughout the day; and indicates the time at which each engine is started and stopped, and the number of revolutions worked. To make the instrument more perfect it is intended to attach to it a rain-gauge, which will automatically record, not only the daily rainfall, but also the quantity falling within any given time.

The engines, pumps, boilers, &c., were supplied under a contract with Messrs. James Watt and Co., Birmingham; who, together with a number of other firms, submitted their own designs in accordance with a general plan and specification supplied to them. The foundations, buildings, and sewers were executed by Mr. A. W. Stanley, Hull.

The cost of the pumping station was as follows:—

	£
Engines, pumps, boilers, &c.	8229
Foundations, buildings, and sewers	8873
Other sundry works	1243
Cost of site	3085
Total	£21,430

The pumping station was commenced in February 1883, and formally opened in June 1884, and has worked very successfully since that time.

The average volume of sewage pumped in dry weather is about 7000 gallons per minute, or at the rate of 10,080,000 gallons per day, which is well within the power of one engine; on rare occasions, however, during excessive rains, the volume is considerably greater than all three engines can properly deal with. As a rule the pumps are worked for 8 hours each tide, but during heavy rain the time is extended. The working staff consists of 6 men, 3 of whom are on duty each tide.

The annual working expenses, exclusive of repairs, are approximately as follows:—

	£
Wages of Staff	515
Coals, 650 tons best South Yorkshire, at 10*s*. 2*d*.	330
Oil, stores, water, gas, &c.	130
Total	£975

Drypool Bridge.

This bridge, which crosses the River Hull, connecting the Old Town and the East District, was sanctioned by the Hull (Drypool) Bridge and Improvement Act, 1885; an Act obtained by the Corporation after a severe and expensive Parliamentary contest.

The width of the river where the bridge has been constructed is 180 feet, and the total length of the bridge 197 feet. Of this length a short portion at the east end is fixed, and the remainder movable, swinging on a turntable supported by six cylinders sunk into the bed of the river to the west of the main channel. Two additional cylinders, standing to the east of the channel, carry the west end of the fixed portion, and also support one arm of the movable portion when the bridge is open for road traffic.

Short lengths of river wall have been constructed at the ends of the bridge. These walls are composed of cement concrete, 6 to 1, faced with Bramley Fall ashlar; and are carried upon piles, 15 feet long, driven 4 feet into the boulder clay, or to a depth of about 40 feet below high water level.

The cylinders are of cast iron, 8 feet diameter at the base, diminishing to 5 feet at a height of 18 feet above the base; and were sunk in the usual way, by excavating from the inside and weighting on the top, to a depth of 45 feet below high water, or about 20 feet

below the bed of the river. When sunk they were filled with cement concrete, 5 to 1, and each tested with a load of 200 tons. The six main cylinders carry heavy cast-iron girders, over which works the turntable, consisting of 21 turned cast-steel rollers, 2 feet diameter, tied in by wrought-iron radius rods to a central pivot, and running upon a turned cast-steel roller path, fixed to the cast-iron girders. The upper roller path is also of turned cast steel, and is fixed beneath a massive framework of wrought-iron girders, carrying the main girders of the bridge.

The main girders are of an open trellis construction, 163 feet 4 inches in length, and of a maximum depth of 19 feet, and, as will be seen from the lithograph, p. 82, their outline is somewhat unusual. The two arms of the bridge are of unequal length, the long arm over the main channel of the river measuring 108 feet 4 inches from the centre of the turntable, and the short arm 55 feet, and the difference in the weight of the two is counterbalanced by 140 tons of cast iron stowed at the end of the short arm. The top and bottom booms of the main girders are of inverted trough section, built up of plates and angles; the number of plates, both at the top and sides, varying at different points, to correspond with the varying strains. The vertical and diagonal members are composed of channels, tees, and flat bars of different sections. The end bays of the short arm are cased in to receive counterbalance, and the sides of the casing are ornamented by panels bearing the arms of the Admiral of the Humber.

The main girders are 20 feet apart, centre to centre, and the carriageway is constructed between them on cross girders, 7 feet 3 inches apart, fixed beneath the main girders. The carriageway is formed of a layer of 6-inch grooved and tongued pitch pine planking, laid longitudinally and bolted to the cross girders, and a layer of 3-inch creosoted redwood planking, fixed diagonally on the pitch pine. The 3-inch planking is calked and made watertight, and upon it are fixed wrought-iron bars for wheel-tracks, and elm battens for horse tracks. Footways are formed, outside the main girders, of 3-inch planking, carried on the projecting ends of the cross girders. The extreme width of the bridge is 35 feet, and the weight of the movable portion is about 480 tons.

The fixed span at the east side of the river is constructed of two plate girders, with cross girders and planking similar to those of the movable portion.

The west approach has been formed chiefly on the site of a

warehouse, which was purchased and removed by the Corporation for the purpose. The east approach is formed by a street which previously existed, but which has been raised to meet the level of the bridge. Both approaches have been paved with granite.

The bridge is turned by two hydraulic rams, each 17 inches diameter, and 4 feet 3 inches stroke, fixed to the cast-iron girders beneath the turntable, and worked by power obtained from the Hull Hydraulic Power Company, at a pressure of 700 lbs. per square inch. Hand gear is also provided for use in case of emergency. In closing, the ends of the bridge run up adjustable wedges, and are locked automatically on reaching the proper point. The working levers for the rams and for releasing the locking gear are arranged so as to be controlled by one man standing near the centre of the bridge; and the principal duties of two other men who are in attendance are, to stop the carriage and foot traffic, and to assist vessels in passing. When the bridge is open for river traffic, a clear waterway of 80 feet exists between the fenders.

The bridge is designed to carry a rolling load of 25 tons on four wheels 7 feet apart longitudinally and 6 feet apart transversely; together with a load of 40 lbs. per square foot on the carriageway, and 120 lbs. per square foot on the footways; and the main span was tested by passing a rolling load of 30 tons over it, while 135 tons of iron were stacked upon it.

The strains upon all portions of the structure were carefully gone into before the preparation of the contract plans. The strains upon every member of the main girders under all possible conditions, were computed by the graphic method; separate series of diagrams being used for—(1) strains due to dead weight while the bridge is swinging; (2) strains due to dead weight and full distributed live load, with the rolling load at various points, while the bridge is supported at the ends; and (3) strains due to dead weight and rolling load, together with various portions of the distributed live load.

The contract plans, 13 in number, which show almost every part of the work in detail, were lithographed full size, and copies supplied, together with copies of the specification and quantities, to the contractors who proposed to tender. The ironwork and woodwork of the bridge, and the timberwork of the fenders, were executed by Messrs. J. Butler and Co., Stanningley, near Leeds, and the river walls and approaches by Mr. T. B. Mather, Hull.

The cost of the works, exclusive of Parliamentary expenses, compensation, and purchase of property, has been as follows:—

	£
Ironwork, &c.	12,102
River walls and approaches	5,682
Other works	766
Total	£18,550

The works were commenced early in 1887, and the bridge was formally opened in September 1888.

Strickland Street Footbridge.

This bridge, which is now in course of construction, is to cross the goods line and sidings of the North Eastern Railway, to the north of the Albert Dock, its object being to afford an additional means of access to the quays of such dock.

The bridge is in one span of 202 feet 6 inches, supported at the ends by brick piers, constructed on piled foundations; and is approached on the north side by a bridge already constructed over the Hull and Barnsley Railway adjoining, in addition to a flight of steps from a footpath between the railways, and on the south side by a flight of steps from the dock quay.

The main girders are of the bowstring form, 211 feet 9 inches long, and 16 feet deep at the centre, carrying between them, on rolled joists, a planked footway 6 feet wide. The booms of the girders are of channel section, composed of plates and angles, and are connected by diagonal bracing of angle iron and flat bars. The south end of the girders will rest upon rollers, to allow for expansion and contraction.

The bridge, so far as its general outline is concerned, is copied from a bridge of the North Eastern Railway Company at York, but the strains and details have been independently computed and worked out.

The works are being executed under a contract with Messrs. W. Richards and Sons, of Leicester, and the contract sum is 1574*l.*

Bridges over Agricultural Drains.

As already stated, the borough is severed by five large agricultural drains, and over these the Corporation have found it necessary, from time to time, to erect bridges. Several wrought-iron girder

bridges, of a span of 40 feet and a width of about 40 feet, have been erected during comparatively recent years, in addition to other bridges of smaller span constructed of brickwork.

The bridges, 40 feet span and 40 feet wide, have cost from 2000*l*. to 2500*l*. each.

Another bridge of similar dimensions, which is now about to be constructed over the Barmston Drain at Fountain Road, is represented by a lithograph (see p. 82). The abutments are of cement concrete, resting upon the boulder clay and faced with brickwork where exposed to view, and the drain is spanned by five wrought-iron plate-girders 44 feet long and 3 feet deep at the centre, carrying a platform of Lindsay's or Westwood and Baillie's steel troughs under the carriageway, and curved plates under the footways. Such troughs and curved plates are levelled up with concrete, upon which wood pavement is laid for the carriageway and flagging for the footway. The piers and parapets are constructed of brickwork, terracotta, and masonry. The bridge is designed to carry a rolling load of 25 tons.

Sessions Court and Prisoners' Cells.

Last year new cells were constructed for prisoners awaiting trial at the Sessions Court and Police Court, adjoining the Town Hall. To obtain the requisite space for such cells, a portion of the Session Court, which was previously an unusually large court, was cut off, but even then it was necessary to construct the cells in three tiers, one above the other, to provide the required number. There are eight cells in each tier, twenty-four in all, each cell measuring 7 feet by 4 feet by 11 feet 6 inches high, and intended to accommodate one prisoner, but capable of accommodating two or three in case of emergency. The Sessions Court has been completely re-arranged and re-seated, but the decoration of the court still remains to be executed. The work has been carried out, under a contract, by Mr. W. Sanderson, Hull, at a cost of 1415*l*.

Public Lavatories.

The Corporation have recently erected a small public lavatory in Scale Lane; and it is intended shortly to erect a larger and much more complete lavatory in St. John Street. The estimated cost of the latter building is 1400*l*.

Other Works.

A number of other works of considerable importance, but which cannot be much more than mentioned in the present paper, have been executed by the Corporation of late years.

In 1885, 1886, and 1887, a sanatorium for infectious diseases was erected; and two additional blocks have been added to the establishment during the past twelve months.

In 1885, 1886, and 1887, two new parks were laid out; the West Park, containing 32 acres, at a cost of 10,000*l.* exclusive of land; and the East Park, containing 52 acres, at a cost of 20,200*l.* exclusive of land.

In 1887 and 1888, a new cemetery, containing 27 acres, was laid out, at a cost of 5100*l.*, exclusive of land, or at a total cost of 18,500*l.*

In 1885 and 1886, two small branch police stations were built at a cost of 2360*l.* exclusive of the value of the sites.

In 1886 and 1887, a market-hall was erected in Queen Street, replacing the old shambles, at a cost of 23,000*l.* The plans for this work were prepared partly in the Borough Engineer's office, and partly by Mr. W. A. Gelder, a local architect, and the works were carried out under Mr. Gelder.

The Corporation have also had in hand a number of street improvements, the most important of which, the Hessle Road Improvement, has already cost 21,400*l.* and will probably cost an additional sum of 4000*l.* before completion.

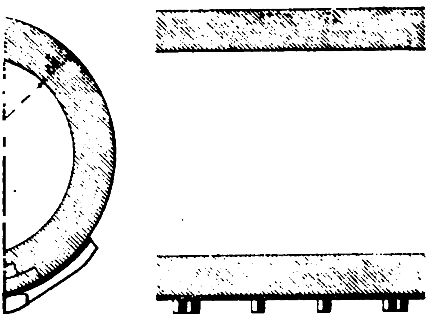
Very important works have also been carried out, under the Waterworks Engineer, in connection with the Corporation Waterworks; and an additional pumping station, with three engines, each capable of pumping three million gallons per 24 hours, is now being erected.

The Author, in concluding, desires to acknowledge the valuable services rendered by his Assistant Borough Engineer, Mr. F. W. Bricknell, Assoc. M. Inst. C.E.; his Chief Engineering Assistant, Mr. W. Oxtoby, Assoc. M. Inst. C.E.; and his Chief Architectural Assistant, Mr. T. Woodhouse, who, in their several capacities, performed important duties in connection with the design and execution of most of the works described; and who prepared the plans which have been reproduced and attached to this paper.

ACE, HULL

BRICK SEWER

CRADLING AND INVERT BLOCKS



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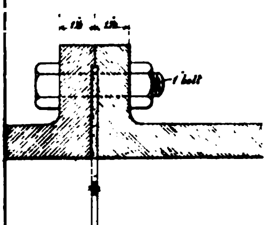


HULL (WE

RIDG

DRAIN AT

DISCUSSION.

Mr. Mawbey: I am sure we are very much indebted to Mr. White for the very kind way in which he has received us, and for the very excellent paper which he has read. It is impossible for us to go away from a large town like this without carrying some extra knowledge with us. Some time ago, as you know, I took a great interest in Hull, and therefore perhaps it is more interesting to me than to many of you to come here. I have very great pleasure in meeting Mr. White here, and listening to his valuable paper. I should like to mention one or two things, and I believe that Mr. White will accept them in the spirit they are made. I should be happy to see him successful in the town. I do not think we can find a more difficult town to drain than Hull, which is so low and flat—the average level of the streets being only nine feet above Ordnance datum, while the level of high water at ordinary spring tides is about twelve feet above Ordnance datum. Mr. White has told us that the sewers are flushed regularly, and he also mentions that they send men into the sewers to clean them out when necessary. They have, it seems, been successful in getting a very fair gradient—one in 3000, which is very fair for a 6-foot 6-inch sewer. From the high water marks one might think they might do more in flushing instead of spending so much manual labour in the sewers. I have no doubt at all that Mr. White has very carefully calculated the strength of the iron pipes he has laid in the most treacherous ground. It did occur to me that it would have been safer, not only to have embedded them in concrete, but also to surround them with concrete. I have in two instances seen 6-foot pipes fractured with the weight of earth when not so protected. The pumping station of the West District is certainly a very fine piece of work, and the engineering staff of this town is to be very much congratulated on the way in which that work has been carried out. I need not go into the details of the work, for we talked it over on the spot. I notice you are going in for a great expenditure in street paving. I should like to know to what extent you are going to adopt wood paving. We are now laying a tremendous amount of wood paving in York; everybody is crying out after it, and I am rather afraid of carrying it to a very great extent in streets where the traffic is heavy. I should like to know your views. I am surprised that you have

noticed no difference between creosoted and uncreosoted blocks. We found in York that the wood pavings put down a few years ago —before I went there—is rotten already, and it was not creosoted. The Corporation also laid some creosoted wood pavement twelve or fourteen years ago, and it looks as if it had a life of five years more. 5-inch wood paving has cost us on the average 10*s.*—the last we have put down cost 9*s.* 7*d.*, made up of 7*d.* for hacking up, 2*s.* for cement concrete, 6*s.* for wood paving, if not creosoted, and 1*s.* extra for creosoting. We intend to creosote everything we put down. I am rather surprised that Mr. White does not go in for concrete paving in Hull. You have cement on the spot, and you have not to pay carriage like we have; and yet we find, as well as in the Midlands, that it pays to put down cement concrete. We have some extensive pieces down, and we believe it is going to last quite as long, if not longer than flagging. It costs us 3*s.* 6*d.* or 3*s.* 7*d.* per yard, but we put it down according to the best of our knowledge. We put hard rubbish under it, and then it comes much cheaper than ordinary flagging. The Drypool swing bridge we have all had a very great treat in inspecting. Not only the bridge itself but the magnificent working of the bridge, and the details of it have been carried out in an exemplary manner. Mr. White tells me, that instead of punching the holes in the ordinary way, every hole has been drilled so that the rivet shall fit exactly. There is one thing it would be very interesting to know, and that is whether the Home Department sanctioned cells so small as those some of them had seen in connection with the Sessions Court. Those cells are very small. We have been getting out designs for the Law Courts in York, and we have gone in for nothing so small as this, for we have been given to understand that the Home Department would not sanction it. Of course I understand that prisoners are there only temporarily—waiting for trial—and not there week by week.

Mr. Gamble: The paper speaks so much for itself that there is not much left that we can criticise, but as an amateur photographer, and one who has spent some considerable trouble in the mechanical reproduction of photographs, I should like to compliment Mr. White on the way in which the paper is got up. I am sure it is quite a treat to see the photographs so well taken and so beautifully reproduced. I don't wish to appear greedy, but I think if a small map of Hull had been attached, we should have had one of the most complete papers I ever came across. In the paper

it is stated that the Corporation take over new streets under the 146th section of the Public Health Act before they are macadamised. I suppose this is to keep clear of the 152nd section, and the result of the West Ham case, in which the judge said that roads must be paved and covered with metal before they would be taken over. I suppose in Hull all are taken over by agreement. In the lithograph of section of the chimney at the pumping station there is no internal flue shown. Does Mr. White think they will be able to do without it? That is all I have to say, except that I am very pleased to be here to-day.

Mr. Brown: I have two or three questions which I should like to ask Mr. White. Has he tested the bricks used in the sewer with water, as to the amount they will absorb? Some bricks absorb a great deal. Another question is respecting the ventilation system adopted in the town; whether he relies wholly on surface grates or whether he has any up-cast shafts. Then Mr. White gives the proportion of concrete as 8 to 1; is it 8 to 1 of stone, or is it a mixture of stone and sand, and if so, what proportion? The advisability or otherwise of iron sewers in Hull has also been referred to, but if Mr. White has erred at all in this matter, I think he has erred on the right side. I should also like some information respecting the pavings which are referred to in the report. These are rather important. The next thing is that asphalte is mentioned; is it pitch and tar, or is it asphalte? We often get led astray by the term asphalte. With respect to the pointing in the sewers, I should like to know if it was designedly omitted or whether it was an oversight. I noticed that the brick sewers were not pointed at all in the inside.

Mr. Wike: I should like to ask Mr. White a question about the bridge which he has designed. He says that he has made provision for a rolling load of only 25 tons. Does he think this is sufficient? The other day I had an excessive load in Sheffield—about 45 tons. I was told that this was a trifle, as last year a casting was moved which weighed 150 tons. I do not suppose it went over a bridge, if it had I would not have given much for the bridge afterwards. Then as to granite setts, I represent a town which has streets with very steep gradients indeed. Some of the gradients of the streets are from 1 in 12 to 1 in 14 or 15, and there are serious complaints about the slippery state of the granite setts. We have tried various kinds of granite, and they are all found so slippery that we have had to go back to the

gritstone pavement. But that is very soon worn out, and I should like to know Mr. White's experience as to the slippery nature of Mount Sorrel granite, and if any other granite has been used in Hull of a less slippery character. With reference to the private streets—in constructing macadamised streets, Mr. White says that the coat is 2½ inches thick, made of macadam which will pass through a 2½-inch ring. I think it will be rather difficult to get that thickness with 2½-inch material.

The CHAIRMAN: I am very reluctant to interfere with discussion, but I think the Association has very rarely had such an elaborate and carefully-prepared paper, dealing with so many subjects, at any of its meetings. Almost every speaker has mentioned his indebtedness to Mr. White, but the lithographed drawings attached to his paper are altogether unique in the history of the Association. I believe I am right in saying that they are drawings which cannot fail to be of service to the Association. We have been somewhat tardy in printing our 'Proceedings,' and in illustrating our papers, but I shall certainly, as a member of the Council of the Association, whenever we come to deal with this paper, advocate every drawing which Mr. White has prepared being inserted in the 'Proceedings,' if the funds at our disposal will admit of it. They will form a record far more valuable, probably, than even our discussion here to-day, to the members of the Association, who are large in numbers as compared with those present to-day. What we are now saying, will go forth in the 'Proceedings,' and as members of the Association we have now to deal in a professional spirit with the paper just read. I think Mr. White will take any remarks which have been made by previous speakers, or which may be made by myself, in the spirit in which they are intended, and will appreciate them as being made with a view to obtaining all the information possible. He has already been flooded with questions, and I think we can scarcely expect him to reply to them all here to-day. But if time does not permit, or if he feels that he can do it better hereafter in writing, so that it can go into our 'Proceedings,' I am sure we shall all be glad to have the questions as fully answered as he may be able to find time to do it. The object of the questions is to give the fullest information possible on so elaborate a paper. The diversity of subjects touched upon is so great that I shall certainly not attempt to deal with them all, but there are naturally a few things that strike one in reading the paper. I can quite understand that Mr. White felt some diffidence

in elaborating the paper too much, because it would have been somewhat unwieldy if he had gone into great detail, but still I think it would have been useful to have supplemented with certain information various points. Take for instance the question of sewerage. What occurred to me in looking at that outfall, 6 feet 6 inches in diameter, was this, seeing that it has a gradient of only 1 in 3000, what is the area that it is intended that sewer should drain, and what amount of rainfall is it supposed that it will provide for over the drainage area? I should like to have known this, because there is a great diversity of opinion upon the sizes of sewers in various towns. I do not suppose that any fast rule can be laid down for all towns—they must be dealt with upon their merits and according to the circumstances of the particular case—but if I remember aright that sewer is for the eastern part of the town. The paper gives the population of the East District as 44,000. That population, ordinarily speaking, would not occupy a very large area, so that it may be that the sewer provides for a very large quantity of rainfall, and then when we come to the pumping station which we saw, we have there three sets of engines, each capable of dealing with 14,400,000 gallons per day. There again I should like to know what area the engines are supposed to deal with? These, I think, are for the western district of the town, where the population is 152,000, without the area being given. We have very heavy showers to deal with sometimes, and I think it would be next to impossible in such sewers to deal with a very heavy rainfall. I believe something has been said to the effect that these three engines had been overpowered on certain occasions. That would not surprise me, but at the same time the difficulty arises whenever you cannot get an outfall by gravitation, and, therefore, whenever we have an example we ought to have the fullest information thereon we can get. I shall be very glad if Mr. White will supplement his remarks as to rainfall in any way he can. The inclinations of the sewers, the paper states, vary from 1 in 450 to 1 in 3000, and I think Mr. White tells us that they are self-cleansing, and are made so large that a man can get into them to cleanse them. But the paper does not tell us whether there are any flushing arrangements for cleansing them other than by manual labour. I should like more information on this point, because it is a very vexed question as to what gradient is self-cleansing. If sewers of 1 in 3000 are self-cleansing in Hull, and we know all the circumstances, we can form an opinion as to

whether that gradient in another place would also be likely to be self-cleansing. We have known many cases of sewers with better gradients than 1 in 3000 which have not proved self-cleansing. Probably the more usual rule now being adopted is to take something like a fair average flow of the sewage, and to get a gradient which, according to the size of the sewer you are going to lay down, will give you, at any rate, something like 2 feet per second. That has, I think, been proved fairly well to be a self-cleansing velocity. If this gradient then, with an average flow of sewage, gives a velocity of 2 feet per second, I can understand it being self-cleansing, but I have known sewers, even 1 in 1500, which have not kept themselves clean; that is, they have silted up, for various reasons. Then, as to the ventilation, the paper states, I believe, that the manholes are 100 yards apart, and I think it has been said that the manhole covers are open. I should like to know if there have been many difficulties here with open covers, as there have been difficulties in other towns. If you had self-cleansing sewers well constructed, and your private drainage equally well carried out, I am very strongly inclined to the opinion that open gratings ought not to be a nuisance. Nevertheless, in many towns, they have had to be closed, and shafts substituted for them, and therefore it would be well to know whether or not there have been any difficulties in Hull. As to the various kinds of roads, I cannot say that I can see why Mr. White should have taken the view of the case set forth in his paper. It certainly does not seem to me to be quite the way in which it is usually done by other people. It is here stated that granite pavement costs only 5¾*d.* per yard per annum, wood pavement 11¼*d.*, and macadam 10*d.* per yard per annum. In the first instance, we have granite pavement at a first cost of 10*s.*, and when we come to the wood pavement, Mr. White seems to take it for granted that the first cost of wood paving at 10*s.*, will require renewing every ten years at a cost of 7*s.* If he can do that in Hull, he will be more fortunate than any town I know of. But I think Mr. White has not made out a case anything like bad enough against macadam. The cost is put down as 10*d.* per square yard; but remember, on the same basis as the other pavement, you must add to this 3½ per cent. on the original outlay. There is a general impression on the part of the authorities that a macadam road is very much cheaper, simply because it costs very much less in the first instance. In Leicester,

we can make a macadam road at a first cost of from 3*s.* to 3*s.* 6*d.* per square yard, but in Hull I suppose it will cost you something like 5*s.* If the stone costs 9*s.* 6*d.* per ton, I cannot quite see how the maintenance is to be done for 10*d.* per square yard. In other words, I make out that macadam would cost 1*s.* 2*d.* per square yard, so that macadam is much more costly than anything else I know of. Coming to the Drypool bridge which we have seen, I must say that I think every possible praise is due to Mr. White for the very excellent manner in which the work was carried out. I think it does Mr. White and his staff very great credit indeed. There are several bridges of that kind, of course, throughout the country; but, so far as I know, I think this will hold its own against any of them. Then, I wish we had more information about the refuse destructor, because there seems to be a wrong impression on the part of many authorities as to the cost of destroying town refuse. Therefore, statistics on this point would be very useful and much appreciated. The pumping station which we saw, I think we were all very pleased with. The engines, so far as I understand engines, are well designed, and I think the work altogether is exceedingly well carried out. I am surprised to find that Mr. White has been so successful in keeping out the ground and subsoil water, with the measures he has adopted. I think this would generally be found very difficult under like circumstances, and it is pleasing to see that he has been successful in making his foundations so water-tight as they are. I think it would have been well if we had a summary of the cost of these and other works during the last few years. Mr. White tells us that since 1885 a sanatorium for infectious diseases has been erected, and two new parks laid out; also that in 1887 and 1888, a new cemetery was laid out, and in 1885–86, two small branch police stations were built. I am sorry that we have not had time to see the market hall. All these things show that the Association ought to have visited Hull long before this. I hope it will soon come again, and that the members will flock here in much greater numbers on another occasion. I have, as I said before, much pleasure in being here, and Mr. White will, I am sure, understand that the questions that have been asked have been put for the purpose of gaining information. We have present here to-day, the Waterworks engineer, and we shall all be pleased to hear any remarks from Mr. Bruce.

Mr. B. J. E. Bruce: I only knew a few days ago that you were

going to have your meeting here to-day, and therefore I have not prepared much to lay before you. If I had had some notice I should have been very glad to have read a paper on our waterworks, because I think they are of very great importance. As the time is advancing, Mr. President, I might just say that I think it might not be uninteresting to the Association to have a brief account of the Hull waterworks. Prior to 1844 the water for the supply of the town was obtained from springs rising to the surface of the ground at Springhead, situated about 2½ miles west of Hull. The volume of these springs proving insufficient, works were established at Stoneferry, on the river Hull, at the outskirts of the town, with a view of drawing water from that river, and after filtration adding it to the spring water for the supply of the inhabitants. These works were completed in 1846, and remained in operation until 1865, when the river water was shut off, and borings made at Springhead with satisfactory results. The springs issue a little above the ordinary level of the river Humber, and are located at the foot of the eastern glacis of the Yorkshire wolds, which stretch about 20 miles northwards, and contain an area of water-bearing chalk of over 400 square miles. At a depth of 175 feet from the surface in one bore-hole, and at a depth of 235 feet in another bore-hole quite contiguous, a bed or seam of flint nodules 12 inches in thickness was pierced, and a vast increase of water obtained. The fact of the bed being reached at a difference in level of 60 feet in two bore-holes only 40 feet apart, shows that a dislocation existed between the two. To this circumstance, and to the fractured character of the rock which accompanies all dislocations of the kind, may be attributed the abundant supply of water, amounting to four million gallons per day, which had up to this period been obtained. From 1865 to the present time nine additional bore-holes have been sunk within a radius of ¾ of a mile, with headings connecting the same to controlling shafts, and the yield of water has been increased to about seven million gallons in 24 hours. With a view to further augment the supply to an extended district and increasing population, the Corporation obtained Parliamentary powers in 1884 to erect a pumping station, on land acquired for the purpose in the parish of Cottingham, about four miles north-west of Hull, some little distance from the foot of the wolds. This land includes the site of the springs known as the "Mill Dam Springs," which have yielded about 4½ million gallons per day of excellent water. The underground

work was completed a short time since, and the engine-house buildings are in an advanced state. The machinery is now upon the ground, and I anticipate that this third pumping station will be in operation towards the end of this year. I should be glad if the members of the Association could spare time to visit our pumping stations, which I am sure would prove interesting. I think next time you visit Hull you ought to give us at least two or three days, because we have numbers of works of very great interest. In such a case as this you have really too much to grasp in a short time. I am very much obliged to Mr. White for inviting me here to-day, and I thank you for hearing me this afternoon.

The Chairman: We must be very much obliged to Mr. Bruce for giving us this information about the waterworks of Hull, and I think he has rightly inferred that if we ever come to Hull again, we might take it for granted that we shall have a very hard day's work before us. So that, I think, we shall have to make two days of it. I should like Mr. Bruce and Mr. White to lay their heads together and see if they cannot get the annual meeting of the Association to come to Hull, and then we shall have three days of it. I shall be very pleased if Mr. Bruce will allow his description of their waterworks to go into our 'Proceedings.' If Mr. White can supplement his paper by giving the information sought by those who asked questions of him, I think it will be very greatly appreciated by the members of the Association.

Mr. Crummack: I should like Mr. White to go into details respecting the macadam. Macadam is not a cheap thing for paving the roadways, and he puts down 10*d.* per yard for twice coating. As far as I can gather, one coating will cost about 9*d.*, and if you add the interest spoken of by you, it will bring it up to 11*d.* for one coating only.

Mr. White: Mr. Mawbey has referred to the strength of the iron piping of the outfall sewer. As to this matter I may say that I am perfectly satisfied as to the strength of the piping, and its ability to withstand any weight that may come upon it; and I do not think we can improve its foundations. As to the wood pavement which we have laid without creosoting, I do not think we should have so laid it if it had not been of exceptionally good wood. We considered it good enough to be put down without creosoting, but as a rule I should certainly creosote the wood. The plans for the prisoners' cells were submitted to the Home Office and approved by them. We had but little space to spare, but I certainly think

the cells are quite sufficient for the purposes for which they are intended; they are only for prisoners awaiting trial, and are never occupied during the night. Mr. Gamble has referred to the taking over of streets, made by private owners, before their completion. I think we are quite right in taking over the streets, under the section I referred to, before they are completed, also in taking over macadamised streets. Streets made as Private Improvement Works, under the 150th section of the Public Health Act, I am aware, cannot be taken over until completed; but I think we are acting legally in making them as macadamised roads and taking them over when made. This is a point which was discussed at the meeting in York about twelve months ago, and the Town Clerk of York then gave us his opinion on the subject, which was to the effect that the streets might be macadamised, and it has been our practice to macadamise and not to pave them. Mr. Brown has enquired as to what extent the bricks used in our sewerage works are found to be porous. We have never tested them for the purpose of determining this; but have never found any quantity of water come through them. As to the invert blocks, it is always the practice in this borough to make them of ordinary sewer bricks, and I think the blocks so made are preferable to stoneware blocks. Mr. Brown has also enquired whether the old 6-foot 6-inch outfall sewer keeps itself clear of detritus. It does not keep itself perfectly clear, although no large amount collects; but I do not think it is to be assumed from this that a sewer of the same size, laid to an inclination of 1 in 3000, would in all cases keep itself practically clear. As to ventilation, with few exceptions open gratings are used on the manholes throughout the borough, which, as a rule, are 100 yards apart. On some of the old sewers they do not occur so frequently. We occasionally have complaints of fumes from the ventilators, and sometimes are obliged to put on a close cover, but we avoid putting on close covers as far as possible. The number of complaints as compared with the number of ventilators is very small. In some cases, where a surface ventilator is objectionable, we carry a ventilating shaft up an adjoining building. As to the proportions of coarse and fine materials used for concrete, the proportion depends upon the nature of the material, and it is my practice to specify that the quantity of small material shall be sufficient to fill the interstices of the large. The asphalte referred to is ordinary pitch and tar boiled in the usual way. Respecting Mr. Wike's remarks as to the strength of the

Drypool Bridge, I think it was unnecessary to provide for a greater load than 25 tons, although we have had loads in this borough reaching 45 tons. In the Fountain Road Bridge the girders are too far apart to allow buckled plates to be used between them, and it is therefore proposed to adopt steel troughing. In several other bridges in the borough buckled plates are used. For paving, we chiefly use Aberdeen granite, which I think gives as good foothold as any granite obtainable. Some streets are paved with Welsh granite, which is found very objectionable, on account of its slipperiness; and we have also some other descriptions of granite which are more or less objectionable for the same reason. As to the size of the macadam, 2½ inches is the maximum measurement of the stone, and there is no difficulty in getting such stone on with a thickness of 2½ inches. The President has referred to the drainage area of the new 6-foot 6-inch outfall sewer, but I cannot now give that area. The President has also referred to the size of the sewer, but in the case of Hull there are special conditions which render it desirable that the sewers should be much larger than necessary under ordinary circumstances. In the first place, they are tide-locked, and the outlets are uncovered for only a few hours each time, and it is necessary that they should be of sufficient size to discharge a large quantity of water in that short time. As an example of a sewer of insufficient size, we have only to go to our present East District outfall sewer, which is 4 feet diameter. During and after heavy rains the water sometimes stands at a considerable height in this sewer for several tides in succession. Even if you have a pumping station, it is still, I contend, desirable that the sewers should be large, for, as the Chairman has pointed out, it is practically impossible to provide engine power to deal with every rainfall, and a considerable storage capacity is therefore necessary. A large sewer is the best form of reservoir you can have for containing sewage, as it will cleanse itself when it has an opportunity of running, and I think that, under the circumstances, the new sewer is not larger than it is desirable to provide for an increasing district. As to flushing arrangements, we flush from the docks, and also from the agricultural drains which flow through the town, and cleansing by hand is executed chiefly in sewers which we have no means of flushing. In the estimates comparing the cost of granite pavement, wood pavement, and macadam, the first cost of the macadam is intentionally omitted, as the estimates, as stated, are prepared for the purpose of determining to what extent it is desirable in this

borough to substitute granite or wood pavement for existing macadam, and the first cost of macadam, therefore, does not affect the matter. Referring to Mr. Crummack's remarks as to the cost of coating macadamised roads, I may point out that the thickness of new stone provided for in the cost of 5*d.* per yard is much less than that which would be used upon a new street, and where a large quantity of stone is used the cost might be considerably more than 5*d.* In some cases where a road is hacked up and rolled for the purpose of removing irregularities from the surface, only a small quantity of new stone is needed. The paving loan for which we are now seeking sanction is all for granite paving, excepting one street which it is proposed to pave with wood. The Works Committee of this Corporation are very much opposed to putting down any large quantity of wood pavement, on account of the cost of maintenance.

Votes of thanks were unanimously accorded to Mr. White for his arrangement of the meeting, and to Mr. Gordon for presiding.

In the course of the day the Members and Visitors proceeded to the East District and Stoneferry Drainage, Hedon Road, inspecting the great brick sewer 6 *feet in diameter, and the cast-iron sewer* 6 *feet* 6 *inches in diameter. The Alexandra Docks, belonging to the Hull and Barnsley Railway Company, were next visited, under the guidance of the Company's Engineer, Mr. R. Pawley, as well as the Drypool Swing-bridge, of* 80 *feet clear span, over the River Hull, which was opened and closed in the presence of the party.*

The West District Pumping Station was next visited, and from thence the company proceeded to the West Docks, finally viewing Strickland Street Foot-bridge, of 200 *feet span, now in course of construction by the Corporation; and thence returning to the Town Hall, where Luncheon was served, under the presidency of Mr. A. E. White, the Borough Engineer.*

ANNUAL MEETING IN PORTSMOUTH.

July 4th, 5th, and 6th.

ADDRESS OF THE PRESIDENT.

H. P. BOULNOIS, M. Inst. C.E., Borough Engineer, Portsmouth.

Gentlemen,—In taking the Presidential chair of this important Association, allow me to tender you my most sincere thanks for the honour you have conferred upon me, and to assure you that all my best endeavours will be used during my year of office to further the interests of the Association to the utmost of my energy and ability.

When I look back upon the names of the gentlemen who have preceded me during the sixteen years of the existence of the Association I feel that the task I have undertaken is not easy of accomplishment. I shall, however, endeavour by every exertion in my power to maintain the high position which this Association now holds, and if it is possible by any efforts that I can make, and with your assistance, to still further raise it in the estimation of the public, rest assured that I will strive to do so.

In looking through the fourteen back volumes of our 'Proceedings' no one can help being struck with the mass of work which these volumes represent, and what a valuable library of professional reference they form.

Year after year papers have been prepared and read by members of our Association, who have but little spare time for the purpose, and these papers are admirable in every way, and have been written upon subjects which have been deeply interesting to the members, and which cannot have failed to advance us in sanitary knowledge and skill.

In searching through these fourteen volumes I find that no less than fifty-six papers have been read and discussed upon the general subject of drainage and upon questions connected with the disposal

of sewage; all these papers contain most important and valuable information, and are, nearly all of them, based upon the personal knowledge and experience of the writers, and in many cases are descriptions of works which have been carried out from the designs and under the superintendence of those members who prepared and read the papers.

Upon subjects connected with sanitary legislation, and the working of the Public Health and other Acts, so far as they affect the town engineer or surveyor, twenty-seven papers have been read, and thoroughly and ably discussed.

Upon that very debatable and much disputed question, the ventilation of sewers, five papers have been read, which contain some of the best and most reliable information that has ever been published upon this all-important subject.

Fifteen papers have been read upon the question of the water supply of towns, which give descriptions of existing waterworks and valuable details in connection therewith.

The lighting of streets both by gas and electricity, has been dealt with in ten papers, many new points having been given and much information afforded either by the papers or the discussion which followed.

There have been fifteen papers upon streets and their construction, including such subjects as the making of roadways, the proper paving of footpaths, steam rolling, stone breaking, wood pavements, asphalt, and the like.

Upon house drainage and the sanitation generally of the dwelling house, thirteen papers have been given to the Association.

The construction of street tramway lines of numerous descriptions has been considered in seven papers, and there have been seventeen papers upon the following miscellaneous subjects, such as the disposal of house refuse, street watering, the construction of quays, canals, and bridges, infectious diseases, hospitals, both on land and afloat, public parks and pleasure grounds, public baths and wash-houses, telephonic communication, electrical fire-alarms, and other subjects of a most interesting character.

In addition to these, eighteen papers have been read and discussed, which gave the most minute descriptions of all kinds of public works which had been carried out in the towns which were then being visited by the members of the Association, and these works were afterwards visited and thoroughly criticised.

These figures give a total of 183 papers which are recorded in the fourteen volumes of our 'Proceedings' to which I have referred, in addition to many visits which have been paid from time to time, by the members to various interesting works all over the country at our District or Annual Meetings.

Now I venture to think, gentlemen, and I believe you will agree with me, that this is a most creditable record of some of the various works upon which we are engaged, but at the same time, this record falls far short of any adequate description or epitome of the real amount of useful work which is daily and hourly being carried out by members of our profession throughout the country, both on a large and small scale.

In order to show you *how* far short this record falls, I have only to lay the following facts before you.

There are upwards of 1000 gentlemen in this country who are eligible for enrolment amongst us as members, and yet you have just heard in the Report of the Council that we number only 371 members. A still further cause for regret is, that out of those 371 members only 71 of that number have contributed all the papers which I have enumerated to you.

May I then, under such circumstances as these, urge upon you all to do what you can in the future to spare a little time for the purpose of preparing suitable papers to lay before us; and also may I urge upon you the desirability, and even necessity, for each one of us, if we can, to induce our brethren in the profession who are eligible for election, to become members of our Association as soon as possible, and thus derive its many benefits.

There still remains a vast storehouse of knowledge, to be gained only by constant work and experience, upon most of the subjects which I have enumerated to you as having been dealt with at our meetings.

We all only too well know and feel how far off perfection we still are in an adequate knowledge or in a solution of many of the great sanitary problems of the day.

The question of the profitable disposal of water-carried town sewage still remains unsettled.

The most effective method of sewer ventilation is still an active bone of contention.

Whether we shall have public and private lighting by electricity, or remain contented with gas, has by no means yet been settled either by experts or by the *vox populi.*

It is still a debatable question whether wood or asphalt makes the best surface wherewith to cover our roadways.

The practical working of many of the clauses of the Public Health and other sanitary Acts is not all that could be desired, and there are not many sections of the comprehensive Public Health Act, 1875, which could not be well discussed at considerable length; and, in fact, there is no lack of subjects for papers which could come before us as an Association, if members will only be good enough to furnish them.

The above subjects are only a very few out of many which might well engage our attention, and many others will no doubt strike the members who are present, such as the abatement of the smoke nuisance, and the consequent diminution of thick fogs—a very difficult problem to solve without a considerable alteration in the habits of the people.

The avoidance of that irritating and injurious noise caused by the great traffic of our streets; whether to be cured by improved pavements or improved wheels and horses' shoes, or both, or neither, time will show.

The better housing of the working classes has still a future, notwithstanding the great strides that have been made in this matter during recent years.

That unostentatious but necessary work, the collection and disposal of house refuse, is by no means at present perfect, and improvements in this direction can well be made.

The present arrangement for the laying of gas and water mains under our streets is by no means satisfactory, as we unfortunate "road-menders" only too well know. And the removal of the unsightly and sometimes dangerous overhead telephone and telegraph wires to beneath the roadways or footwalks will not be satisfactory unless special means are provided to avoid the necessity of breaking up the surface for repairs or connections, &c.

The rapid growth of these necessities of civilisation, and the addition of hydraulic pressure mains, steam pipes from central stations, and the possibility of gaseous fuel similarly laid on, will before long necessitate legislation in this direction.

These and the application of wind and tidal power, and many other subjects which will no doubt occur to you, are questions which might well be discussed by this Association, in addition to those which bear directly upon the daily detail duties of our professional work.

Speaking for a moment upon the subjects which will engage the attention of your Council during my year of office, you have already heard in their Report certain matters which have been dealt with, and which will still have to be constantly before them.

Our examinations for Pass Certificates are, I believe, daily growing in popular favour, and the proposed registration of the Association can but add to the value of these certificates, gained, as they have to be, by candidates who have to pass a most rigid examination upon subjects of an engineering and sanitary character.

The careful watching of any Bills before Parliament which are likely to affect us as an Association, or individually in our professional positions, will be the duty of your Council, and the *locus standi* which will be given us by the registration of the Association will greatly assist us in these efforts.

The report on the ventilation of sewers which has been necessarily so long in abeyance, will, I trust, make considerable progress before the next Annual Meeting, and many other matters in connection with the prosperous working of the Association will receive our best attention.

It has been the custom occasionally for the President of this Association in his Inaugural Address at the Annual Meeting to give a description, more or less extended, of the works of his own district, but on this occasion I shall ask you to allow me to depart from this custom, as I feel that such a description would be of more value at a District Meeting, when there would be more time than there is at our disposal to-day, and when the paper could be fully discussed, which is not customary with an Inaugural Address.

I hope, therefore, at some future time to welcome you again to Portsmouth, when I should be able to give you a paper setting forth the details of the working of this large borough.

Our proposed visit to H.M. dockyard to-morrow will be rather a new departure from the usual description of visits made by this Association, but I can assure the members that we shall see and be able to examine machinery and implements of a most interesting description; and though we are men of peace, and our duties lie in the preservation of life and health, we shall learn a very great deal by the study of this machinery and those implements, which are constructed and maintained for widely different purposes.

I believe that this Association of which to-day I have had the honour of being elected President, is daily advancing in strength and importance, and that the branch of the profession to which we belong is daily growing in popular favour and esteem.

As the strength of a community is made up of the strength of its individual members, may we one and all strive collectively and individually, by our daily advancement in the arts and sciences, and by the integrity of our conduct and attention to our duties, to advance the profession to which we belong, and the best interests of this Association.

THE RELATION OF LOCAL AUTHORITIES AND THEIR SURVEYORS TO IMPROVEMENTS IN THE SANITARY ARRANGEMENTS OF EXISTING BUILDINGS.

By FRANCIS NEWMAN, C.E., Borough Engineer, Ryde.

In treating of this subject I believe I am dealing with a branch of our work on which a special paper has not been previously read before the Association.

We have, however, had instructive papers which have had some reference to the subject. One, which occurs to me as one of great interest, was that read by Mr. Spencer at Newcastle, on "Inspecting and testing the sanitary arrangements of houses." I do not, however, propose to deal so much with the engineering side of the question, as with the methods of procedure of local authorities in the enforcement of proper sanitary arrangements in existing buildings, and the duties of their surveyors in reference thereto; I should add that whilst I do not expect to contribute any increase to the knowledge of the members on such subjects, I hope my paper may be the means of eliciting the experience and opinions of others on the details of a portion of our work in which the practice in different localities is not so uniform as is the case with many parts of our duties.

I find it necessary to refer first to the practice with reference to drainage and other arrangements in new buildings, because in these the procedure is much more systematic, the model bye-laws promulgated by the Local Government Board having been generally adopted by local authorities, and the sections with reference to sanitary arrangements representing generally the accepted opinion of the great majority of sanitarians; and the control is more effective, as the surveyor is able to insist on facilities being afforded for inspecting every part of the work whilst it is in progress, and before any essential portious are covered up.

In new buildings the surveyor can enforce a definite system of drainage, and particular arrangements for ventilation and disconnection, as well as specific apparatus for water-closets; he has not

to convince anyone that his opinion on sanitary principles is correct, but has merely to enforce the execution in a workmanlike manner of the work as described in the bye laws; on the other hand, in reference to existing buildings, we have to show that the arrangements provided "are not sufficient" or that the premises are, owing to such arrangements, "in such a state as to be a nuisance or injurious to health," and in the generality of cases to convince magistrates of the soundness of our conclusions.

I presume the sections of the Public Health Act under which sanitary authorities most frequently deal with the arrangements of existing buildings are:—

23. "Power of local authority to enforce drainage of undrained houses."

36. "Power of local authority to enforce provision of privy accommodation for houses."

91 to 103. Dealing with nuisances.

The work empowered to be done under sections 23 and 36 may, in default of compliance with notice, be executed by the sanitary authority, and the cost recovered from the owner; but proceedings in reference to the nuisance sections are more cumbersome, and defects that can only be dealt with by those sections are frequently of the greater importance.

I am disposed to think that different localities are differently circumstanced in reference to sanitary arrangements of existing houses. In many of the smaller towns situate on permeable strata, no sewers existed until after the general adoption of earthenware pipes for house drains, and in these cases brick or rubble stone house drains will be unknown; but there are many towns situate partly on permeable and partly on impermeable beds, which have always, since the population acquired an urban character, had sewers of some kind or other, and where the sewers have been gradually changed from brick and rubble stone constructions laid on no system, to sewers of the modern type; and even in these cases new house drains have not been enforced immediately after the new sewers have been constructed, and consequently the branch drains are of various character; whilst it will always be found that even where the drains are not more than 20 years old, there are many arrangements which are now considered undesirable, and which sanitary authorities, if they wish to secure the health of their localities, should deal with and reform.

I think, in dealing with existing houses, it will be found advantageous to treat them as far as practicable as we should new buildings, and I regret very much that a measure was not passed prior to the introduction of the County Government Bill, which would have enabled authorities to apply the same rules to both new and old buildings. Such a measure might have included the removal of other stumbling blocks in the way of sanitary administration, and would not have occupied a tithe of the time devoted to the bill above named.

There is, however, one way of helping ourselves in this matter, which I think has been lost sight of by many.

Our excellent President told me some years ago that he had drafted a bye-law, which had received the sanction of the Local Government Board, with reference to drains forming new connections with the sewers, even although not intended for new buildings, and the Town Clerk of my borough drew my attention not long since to sub-section 4 of section 157, which enables a sanitary authority to make bye-laws with reference to the drainage of buildings, the restriction of this power to make bye-laws to new buildings only, which appears in the prior sub-sections, is omitted from this; this seems to have escaped the notice of the Local Government Board, as no model bye-laws have been issued by them applicable to the drainage of existing buildings. And I think it would be well if localities would submit such bye-laws to the central Board, and endeavour to obtain their sanction thereto; such bye-laws might, with great advantage to the profession, be drafted by the Council of this Association.

I have before alluded to variation in the practice in dealing with the sanitary arrangements of existing buildings. I think there is another way in which the practice in this department varies, and that is that the defects are often dealt with by the medical officer of health and the sanitary inspector without the intervention of the surveyor, and I suppose we should all be strongly of opinion that all works of a structural character, or involving mechanical appliances, whether executed by a local authority or supervised by its officers, should be controlled by the surveyor's department, and that if so controlled, the practice in different towns would be more uniform.

Now in dealing with defective houses I have found one difficulty which would not arise were it clearly laid down that what are good and reasonable precautions in new houses, built under some

public supervision, with precautions against damp walls and damp floors, are also good and reasonable for existing buildings which may not have been built with such care; the difficulty I refer to is that magistrates will generally only make orders to do the minimum of work.

In going before a Court in order to ensure getting an order, it is often necessary that evidence should be given to show that the improvements are absolutely required, and that without such improvements the premises are injurious to health. In practice we are accustomed, in devising works of house drainage and arrangements connected therewith, to provide safeguards, which although wise precautionary measures, it is sometimes difficult to prove are all absolutely necessary, and that injury to health will result from the omission of any part of them.

Take for instance the disconnection of drain from sewer, and the provision of an air inlet on the house side of such disconnection. On a house which has the wastes disconnected, the inlets to drain all properly trapped, and the soil pipe placed at the farthest point of the drain from the sewer, and carried a suitable height above the roof for ventilation, this drain might be trapped near its entrance to the premises, but without an air inlet on the house side of it. In this case the ventilation pipe would relieve the traps from pressure, though there would not be a current of air through the drain and soil pipe, which we think desirable to constantly change the air in the drain; or the drain may not be trapped from the sewer, in which case air will pass from the sewer through the drain and ventilation pipe, still the latter will relieve the traps from pressure. The Local Government Board have recognised the value of this extra precaution and of the system of double disconnection generally, but can it be maintained that the absence of double disconnection causes a house to be in such a state as to be a nuisance and injurious to health?

There then follows another question: if the greater perfection of sanitary arrangements cannot be enforced, is it expedient to give notices requiring them, or simply to limit the notice to such works the omission of which there is no difficulty in proving are injurious to health?

It appears to me that the drainage and other arrangements of existing buildings which need amendment may be divided into two clauses.

1. Those with drains of improper material or of such gradient

as to cause deposit, or drains with the collars of the pipes broken off, and connections made by cutting holes in the pipes, with inside soil pipe or traps pierced with holes, scullery and other sinks or cellar grating in direct connection with the drain, water-closet cisterns supplying drinking water, drain not ventilated, or some of these defects.

2. Those which, although having a fair drain, scullery and other wastes disconnected and drain ventilated, have defective closet apparatus, soil pipe within the house, and the house drain not disconnected from the sewer.

With the first class it is comparatively easy to deal, with the second it is less simple, because, as before stated, it is difficult to prove the absolute necessity of perfection in such matters.

I have before referred to the practice in some places of the authority taking action only on the report of the officer of health or the sanitary inspector, and I have known cases in my own borough where notices have been given, on the report of one of those officers, to disconnect scullery sinks: those scullery sinks have been disconnected, and I have afterwards had occasion to examine the buildings and open the drains, and have found that whereas prior to the disconnection, the scullery waste ran into a brick drain under the sink, which brick drain traversed the scullery and some other part of the building, disconnection, as carried out, simply meant that a trap was put outside for the waste discharge, such trap being connected with the old brick drain under the building.

Now with reference to the designing the improvement of the sanitary arrangements in existing houses, it appears to me very advantageous that all these alterations should be done under the surveyor's direction; but I do not think it right that owners of property should expect the local surveyor to design these alterations for them, but rather they should submit a plan to him which he will examine and give his opinion on, and if satisfactory, they will carry out such plan under his superintendence, as all such work should be superintended by a public officer. The difficulty that arises on this question seems to be this, that an owner of property who removes defects voluntarily is placed at a disadvantage as compared with he who waits until the authority compels him to make the improvement, as the former has to engage the services of a professional man, whilst in the latter case the surveyor sets out in the notice what is required to be done.

Having just referred to the subject of inspection of work in progress, I would say that it appears to me most advantageous to the public that every house drain should be inspected by a public officer before the joint holes are filled in, its joints examined, gradients tested, and a plan taken, which plan should be put upon the town map if that map is of not less scale than $\frac{1}{500}$; but inasmuch as there is not sufficient space for the inspector to initial the map and place the date of the execution of the work, I have adopted the plan of having an inspection book, in which the portions of the drains inspected are entered day by day—a tracing showing the plan of the drains being pasted in the book, and the initials of the inspector, together with description of the gradients and ventilation of the work, being attached to the plan renders the discovery of alterations comparatively easy.

There is another point, and that is the disposition of tenants to seek the intervention of the authority to get something done by their landlords which they are unable to secure themselves; this I think is perfectly legitimate if defects arise after the tenancy has commenced, or if a state of things exists which was thought fairly good at the commencement of the tenancy, but which has become obsolete when the interference is sought; but I have known cases where persons, perfectly able to pay a fee for professional advice before taking a house, within six months after entering into occupation, call upon the local surveyor to put pressure on the landlord, either by reporting to his committee, or by personal action, to induce such landlord to make improvements which the tenant should have required to be done before he entered into occupation.

In some towns, particularly watering places, the system of granting certificates when houses are in a good sanitary state has been put into practice. I have myself thought the system might be used as an inducement to owners to put their houses in order, but I confess I have found many difficulties connected with it; one conclusion I have arrived it is, that such certificate ought to give full particulars of the arrangements, so that alterations or defects subsequently introduced under bad advice may be easily detected.

I have found that where a drainage system was provided with disconnecting trap and air inlet, and an exit for the air through the soil and ventilation pipe which was outside the building, such current had three years afterwards been stopped by a trap being

introduced at the foot of the soil pipe, because the owner complained of a smell from the water-closet, which, by the way, was of the old pan or iron container type, and which was removed before I saw the house the second time.

There is one more point to which I wish to refer, one which I doubt not all those gentlemen whose sphere of duty lies in towns which have had drainage more than 30 years are too familiar with, namely: those drains the responsibility of maintaining which is legally on the authorities, but morally on two or more owners; I mean joint branch drains used by two or more houses, which, but for the interpretation clause of the Public Health Act, no one would deem public sewers.

It appears to me it is for the interest of sanitary progress that authorities should at once recognise and accept their responsibilities, treat these drains as sewers, and reconstruct them where necessary and provide means for their ventilation—that authorities should, in fact, lead sanitary improvement.

There is one other point of interest on the question of these drains to which I would refer: supposing a drain taking the drainage of two houses, and therefore legally a sewer repairable by the authority, ceases to take the drainage of one of the houses, does it cease to be a sewer?

Gentlemen, I trust you will excuse the discursive character of this paper. Although I find I have not by any means exhausted the subject, the paper has extended to much greater length than I contemplated, or I should have commenced writing it much earlier than I did, with the view of spending more time in systematising it. It will, however, I trust, induce interchange of ideas on a subject of much importance.

There is one little thing I should like to add, which did not occur to me at the time, and I should like the opinion of members expressed on the subject. That is the closing of wells which are suspicious owing to their position, but which on analysis show no signs of pollution.

Cases which make it clear that a Local Board can enforce water supply to closets:—

Sherborne Local Board v. *Boyle*: Q. B. D. 18th March, 1880; 46 J. P., 675.
Vestry of St. Luke v. *Lewis*: 31 L. J., M. C. 73; 1 B. and S. 865; 5 L. T. (N. S.) 608.

Cases which settle the question of whether a drain which supplies two or more houses or buildings, but would otherwise be a private drain, being a sewer under the interpretation clauses of the Public Health Act, may be considered as constructed for the private profit of some person, and thus excepted from the sewers for which the sanitary authority is responsible under section 13 of the Public Health Act:—

Acton Local Board v. *Batten*: 28 Ch. D. 283; 54 L. J. Chap. 251; 49 J. P. 357.
Pinnock v. *Waterworth*: 51 J. P. 248.

DISCUSSION.

Mr. Eachus: I have much pleasure in proposing a vote of thanks to Mr. Newman for his paper.

Mr. Joseph Hall: I have great pleasure in seconding the vote of thanks, and in doing so I would like to point out one or two matters in which my experience has been somewhat different to Mr. Newman's. We have a system by which we inspect all houses at the cost of the local authority. An inspector goes round, examines the house and tests the drains, both by the smoke and smell tests, and if everything is right then a certificate is given. If any alterations are necessary, he prepares a scheme, and submits it to me for my approval. Unless the alterations are made—they are not compelled to be done—no certificate is given, and the tenant is warned that no certificate will be given until the house is put in order. This amounts to a condemnation of the house. We have had houses which have stood empty as long as eighteen months, because no certificate was given. With regard to bye-laws, the Local Government Board will only allow bye-laws for ventilation on the house side of the trap, but we get a 3-inch pipe from the outside of the trap carried to the roof, in addition to the Local Government Board provision of the inlet and outlet pipes. This is an important provision. By it you get over the difficulty of sewer ventilation, and as everybody has to do it there is no hardship. It may be said "You are expecting the house owner to ventilate public sewers." But what is the difference whether owners do it themselves, or whether they allow the public authority to do it and pay for it by rates? Then there is the statement about the Public Health Act and public sewers. Mr. Newman has omitted to notice the very important exception to all sewers being public sewers. The section states that all sewers taking the

drainage of two or more houses are public sewers, except where they are made for private profit. Last week the question arose in my town, and our clerk held that "private profit" was a man having made a sewer to save himself cost. In this particular case, he had put in 60 yards of sewer, where he ought to have put in 200 yards. This was done a number of years ago, and now we have served an order on the owners for the houses to be drained separately, and we have got it done. One man was disposed to fight it out, but last night he said, "It has got to be done, and I had better do it."

Mr. Ellice-Clark: I would like to say a few words, not on the details of the paper, but on one or two important principles involved in it. Codes of model bye-laws, as issued by the Local Government Board, have been generally adopted by municipal and sanitary authorities in this country, and Mr. Newman points out that under these bye-laws the duties of a town surveyor are purely ministerial, that he has not to convince anyone the principles of drain ventilation are correct, but has merely to carry out his duty of enforcing the model bye-laws. To put into bye-laws a detailed specification for drainage or similar sanitary work is, in my judgment, a mistake. If the model bye-laws have to remain for a number of years in operation they will become obsolete. Take, for instance, the very question that has been alluded to by Mr. Newman, where a provision is made for a fresh-air inlet and a foul-air outlet to house drains; you will find in the model bye-laws, the fresh-air inlet has to be at a lower altitude than the foul-air outlet. That is statutory, and cannot be altered, but the principle, being based on insufficient data, is wrong. I was inspecting only recently a house in Chelsea, where this principle had been carried out. There was a difference in altitude of 60 feet between the fresh-air inlet and the foul-air outlet, and we endeavoured in vain to establish a current from the "fresh-air inlet" to the "foul-air outlet," so, naturally, reversed the order of proceeding. We inserted a smoke rocket at the "foul-air outlet," 10 feet above the roof, and we found that the foul-air outlet was the fresh-air inlet. That is a very recent experience of mine, but I daresay it could be borne out by others present. In Brighton, and in other seaside towns exposed to gales, it occurs very frequently indeed. With regard to this particular house in Chelsea, we have recommended—for I may say that there were two engineers consulted in the case—that the fresh-air inlet should be

carried very nearly as high as the foul-air outlet. If you put into any bye-laws, which are practically statute laws, details of sanitary arrangements the efficacy of which are not established, it is an exceedingly dangerous thing to do; and Mr. Newman, further on, agrees with me, for he says "he is disposed to think that different localities are differently circumstanced in reference to sanitary arrangements of existing houses." In almost every town, and very frequently in different parts of the same town, different arrangements have to be carried out, and it appears almost impossible to frame bye-laws sufficiently elastic, which go into details for sanitary arrangements, to make them work thoroughly; nor can this be done until sanitary science is an exact science, if that should ever be so. With regard to the paragraph that all structural works should be carried out by the Surveyor, I think there can be no doubt this is the right principle. The Medical Officer of Health has entrenched largely upon the duties of the Municipal Engineer; but it very often depends entirely upon the two individuals, and the engineer should always hold his own in matters of principle like this. It involves a great principle for the profession, and it involves a great principle for the public at large. There is quite enough for a man to study, and to understand, and to practise, in public hygiene, without entrenching upon the work of the Municipal Engineer. With regard to the paragraph in which Mr. Newman speaks of the right of owners to expect the Local Surveyor to design the alteration, as a matter of practice in some of the great boroughs it would be impracticable, because if it were done the surveyor would require to have a very large staff. This is another principle which ought to be accepted by the members of this Association. The Borough Engineer should not be the man to take upon himself a responsibility that very properly attaches itself to owners of property. Upon many previous occasions * I have used the words "that the responsibility for the condition of a building is the responsibility of the owner," in regard to the question of certificates to which Mr. Newman has alluded. In the bye-laws at Hove, and in other towns, it is provided that the surveyor shall give certificates for houses. I have always repudiated giving certificates, and never would give one, and I will tell you why. If you give a certificate, one of the assistants of the surveyor must supervise the work—because this work is so intricate that he must see every detail fully carried out—and he

* See vol. x.

may not have left the premises five minutes before those arrangements are upset by somebody dropping a brick and breaking a pipe, or some simple accident of that kind. Your certificate is issued, and in twelve months something is found wrong with the drains, and if the owner is summoned he will produce the certificate of the Local Surveyor which will be very strong evidence in his favour. What Municipal Engineers should insist upon is this: that upon those who make the profit, those who build houses and own them, the responsibility should be laid. All attempts to cast this responsibility upon public officers should be strenuously resisted.

Mr. Winship: There is one matter upon which I should like to have the opinion of members, and that is with regard to the carrying out of the 36th section of the Public Health Act. The town I represent was drained about 12 years ago, and shortly afterwards the waterworks were constructed. A few years later, we found that only about 30 per cent. of the houses were using the town water supply. We are now serving notices on owners to compel them to put on the water, but we have had about only 50 per cent. comply therewith. I desire to know whether any of the members have taken a case into Court, where a w.c. has no means of flushing, and successfully carried it through.

Mr. Ellice-Clark: Hove had a large number of houses not connected with the town water supply. The authorities there took the opinion of Sir Farrer Herschell, who has since been Lord Chancellor, and he held that you could not compel them to put on a special water supply, so long as the closet was not a nuisance.

Mr. A. T. Davis: With reference to the question put by Mr. Winship, I may say I wrote a letter, bearing exactly on the point, to the *Local Government Chronicle*, and the answer given was that it was competent for the local authority to insist upon the water apparatus. The section, I believe, runs to this effect—that if a house is not provided with a proper water-closet, earth-closet, or privy, the authority may insist upon the provision of one or other of that kind of accommodation, as the case may require. And if a town is properly sewered, and decides to adopt the water carriage system of sewage removal, then I think they should insist upon water-closet accommodation, and where the old middens exist they should abolish them as soon as possible. My Board had such a case, which we took before the magistrates, and they insisted upon water closets being provided, together with proper flushing apparatus.

Mr. ANGELL: We can insist upon proper arrangements, but we cannot insist upon a water-closet. We felt that difficulty at West Ham, like the Commissioners of Hove, and we obtained the power in one of our local Acts; but you cannot, under the Public Health Act, insist upon the laying on of water to a closet. It will be held sufficient if the person flushes the pan with a pail. Mr. Newman has raised three or four legal points in his paper, and there are other legal points; but it is not desirable to instruct the public how they may defeat us. I am constantly overstepping the law; that is to say, in the interests of the public we assume many powers we do not possess, and the public at large do not contest the points. In the case mentioned by Mr. Davis, the magistrate's decision of course is law until it is upset, and if the parties had been sufficiently litigious to go to a higher Court it would have been upset. Then, as to certificates: unless there be a local Act authorising certificates, there is no such general power, and, as laid down by the Local Government Board, granting them is absolutely *ultra vires.* In my bye-laws such a clause existed for years, but, for the reasons given by Mr. Ellice-Clark, I absolutely refused to grant them. Whether or not it is reasonable to grant certificates, there is a difference of opinion. Mr. Newman objects to the Medical Officer of Health and Sanitary Inspector taking upon themselves duties which belong to the Municipal Engineers, but I never object, because it relieves me of a good deal of trouble. All those things, mentioned by Mr. Newman in detail, which should be carried out by the Surveyor regarding the supervision of buildings, plans, and other matters, are desirable and proper, but those who have a great deal of work in large towns cannot find the time to do it. There is always pressing work going on, and we do not have a sufficient staff to do it. They ought to be carried out, but I venture to say there is hardly one member present from a large town who would have the time to give to the work, or a staff large enough to attend to it. With regard to the air inlet and the higher outlet for ventilation, we have frequently found, where we carry out the bye-law rigidly, that a smell from the drains escapes under the front ground-floor window. There is sometimes a difficulty in adapting an air inlet suitable to local circumstances, and I have allowed the inlet to be stopped in many cases, as the least of evils. With the air inlet, you get the pressure taken off the drain and without it you do not get a thorough ventilation. Another point came under my observation a short time ago. In a well-drained

town, if cesspools exist, we have no power to abolish them, unless they are proved a nuisance. In many places there is no evidence of injury to health, and in some cases we found we could not compel connection with the sewer, though within 100 feet. As to well water, if the water cannot be proved impure you cannot prohibit its use; but if it is injurious to health you can of course compel a proper supply.

Mr. G. E. Eachus: I should like to say that under the 36th section you can enforce, not perhaps directly, that a proper flushing apparatus should be put on. If you give notice to the owner that the house is to have a sufficient water-closet, you put him in the position to prove that he has made it sufficient. In order to make it sufficient, there must be, not the passing of water in occasionally, but a proper flushing apparatus. There are one or two cases reported in Glen to the effect that you can make the owner do this. Of course there are many ways of giving notices, and the great difficulty is for the officer to put the notice in a way that it will be accepted as binding. There was another point raised as to the question of private profit in sewers: when does a drain become a sewer? and so on. I had occasion to advise a local authority on that point, and we took the opinion of Mr. Finlay, Q.C. As far as I can remember, unless a man laid down a sewer and received a rent for wayleave, the sewer could not be considered as one put down for private profit; and all sewers for two or more houses are vested in the local authority. There is a great deal of law in the Public Health Act, but it is on the tact of the officer the successful dealing with the various cases chiefly depends.

Mr. Lobley: The practice I have carried out for many years is, not to regard these drains as public sewers. I am quite prepared to admit that if you ask Counsel's opinion he will tell you what Mr. Eachus has said. But until recent years we have had no Judge's opinion, and the decided case is not entirely on all fours with the cases in view at present. Of course I make a distinction with different cases; I do not ignore them all as sewers. If the drain or sewer is made, under the 1875 Act, by the authority, and charged to the owners, then the sewer becomes vested in the authority. Then there is the case of a sewer belonging to one or more different owners. This I should be very reluctant to regard otherwise than as a public sewer. But where it is on private ground, passes through perhaps one or more backyards, but not under any street or passage that can be brought under the 150th

section, and where it all belongs to one owner, there I think the case can be considered to be one for the profit of the owner, and where you can easily show it has been made to save expense to the owner than if he had had to drain each house separately. If we were to consider them as public sewers the cost of them would be very much greater than maintaining existing ordinary sewers at the public cost, as the difficulty of getting at them would often be great. And where it belongs to one owner I think it can be fairly considered to be made for his own profit. At any rate until a Judge's opinion to the contrary has been given, we ought to look upon it in that way. In my borough, if anyone objects to paying, we tell them that we are quite ready to fight the case and carry it to a higher Court. In fifteen years we have never had anyone willing to fight a case, and I am quite ready to wait until they do.

Mr. LEMON: An owner comes to the local authority and says "I have three or four houses here which are more economically drained through the back," and the local authority wisely consents that he should be allowed to do so. It is quite evident that the owner has done that for his own advantage and profit, and it is a monstrous principle to say that because the local authority have done that, the local authority is for ever to maintain that drain and keep it in order. I would suggest a little way out of the difficulty. Get the owner to add to the application that he will agree afterwards to maintain the sewer. Whether it would be binding in law I cannot say, but it would be an obligation to him as an honourable man that he could not gainsay. Then there is the important question raised by Mr. Clark. I have long been of opinion that municipal authorities and engineers are treading upon dangerous ground when they take upon themselves the responsibility of looking after house drains. When I became a borough surveyor I was very anxious to do everything. That is a great mistake, as you will find when you get older. Then I was very anxious to have the control of everything. That is another mistake. I wished to give a certificate that the houses were properly drained and according to the bye-laws, but I soon found that to be impracticable and impossible. In the first place the Corporation would not allow me a sufficient staff to properly supervise these drains to give a certificate. I have never given a certificate, and I think I have acted wisely in that respect. I do not think any local surveyor should be asked to give a certificate to that effect. In the first place the bye-law is *ultra*

vires; and second there is the supervision and subsequent control. The house may have been drained on the most scientific principle, but some botching plumber may come in a week hence and upset everything. A more illogical principle than that could not be. I would say to the younger members of the profession "If you have given certificates, give it up altogether." In the first place they are illegal, and in the second they are illogical and valueless.

Mr. C. G. Lawson: As to the question of giving certificates, the Local Government Board admit they have power to pass such a bye-law, and my Board has got that bye-law. The Swindon Local Board had a case carried into the superior Courts, and the judges decided that such a bye-law was a perfectly legal one. For some time the Local Government Board refused to grant the bye-law, but after the decision in the Swindon case they have granted it.

Mr. R. A. MacBrair: I should like to discuss the proposition laid down by our ex-President Mr. Ellice-Clark. I agree to a certain extent that the law, or the model bye-laws, should not enter too much into detail, but there are two sides to the question—there is such a thing as being too vague. I will give an analogy to illustrate my point. The old building bye-laws contained a clause fixing a minimum—generally about 8 feet—for the height of rooms. In the new model bye-laws this is omitted; it vaguely states that there must be "sufficient ventilation," thereby taking away all real power over the height of rooms; so there is such a thing as being too vague and having no definite regulations. There is another matter I should like to mention and ask the opinion of one or two members upon. We have had no lengthened experience of cast iron ventilating pipes for sewers. Some years ago I erected 25 or 30 4-inch to 6-inch pipes, to ventilate the public sewers of a town. About a year ago I had occasion to open one; the result was disheartening—it was quite blocked up. I found nearly every one of the 25 to be in like evil case; every one was stopped up, simply from the scale in the bottom. Oxidation had set in and the scale tumbled down. I am afraid that three-fourths of all the house ventilating pipes are so blocked up. I adopt a simple expedient. At the bottom of the vent pipe I put a 2-foot pipe on end to allow the scale to tumble into, or else build a small brick cesspool or chamber. When should a branch drain become a sewer? On page 7 of the paper just read it says that "authorities should at once recognise and accept their responsibilities and re-

construct them where necessary, and provide means for their ventilation." I say decidedly "No." If a man likes to erect two houses, selling one of them, and at the top of the passage between them branches off drains right and left, I do not think local authorities should accept the responsibility and have to repair and clean out the drain in the passage.

Mr. Ellice-Clark: Mr. MacBrair thinks we should not be too lax in drafting bye-laws. About five years ago I spent a great deal of time in obtaining all the bye-laws in Lancashire and Cheshire; and I read a paper at Liverpool and Hove * on this subject, in which I endeavoured to draw a distinction between matters on which it was possible to have hard, fast, and rigid laws, and where it was not possible to have strict laws; but where there are delicate details, such as have been alluded to, I think you must have bye-laws either elastic or vague.

Mr. J. Gordon: The character of the paper Mr. Newman has been good enough to read is certainly of a discursive kind, and I do not see that any practical result can come of it, except by an interchange of ideas. I was naturally anxious to hear the opinions of many of the younger members of our Association, and we hear that there are diversities of opinion upon very many points; and I must confess I am a little out of unison with the views expressed by Mr. Lemon and Mr. Clark as to the inadvisability of expressing too much opinion in your bye-laws. I have found it a great advantage to make what you may call a new departure. If you go into a town and find the sanitary arrangements very defective through laxity of the application of the bye-laws, and that there has been no definite instructions given to the builders or architects, you naturally begin to put your knowledge of sanitary laws into force. If your bye-laws are lax, as in the instance Mr. MacBrair has mentioned, you have no doubt very great difficulty; and it is only by moral persuasion that you can get them to do what is required. Possibly the case I am going to refer to is hardly a fair sample of what can be done. In the case of Leicester we not only have the Public Health Act, but a private Act. Under the latter I have made regulations and have gone so far into detail as to give the manner in which a house should be drained, and have given general examples likely to be useful to Leicester. Of course rules cannot be laid down for the whole country, but you may fix and give fairly definite instructions for each town, taking each in its

* See vol. x.

general details; but I think it also possible, in giving and making these regulations, to make them sufficiently elastic to leave you with a comparatively free hand to change a regulation where you think it is not properly applicable. I have found, at any rate in Leicester, that the general regulations which I drafted have been of great use, not only in instructing the builders, but the architects themselves, and they have been very grateful to have something before them. I have never found much difficulty in carrying the regulations out, and builders have willingly taken my advice. In the case of disconnection, for instance, I am pleased to hear in some respects that there is considerable unanimity with regard to disconnection; but there are cases, which I am quite sure every member has met with, where it is extremely difficult to carry it out. Therefore, if you have a fixed regulation of that kind, which makes it compulsory to disconnect a house, you place yourself in a great difficulty if you cannot depart from it. I have very many instances where I have advised it should not be done. Mr. Newman, in his paper, tells you of the very great difficulty in dealing with old houses. There is not the slightest doubt that that is so. The surveyor, knowing his business, inspects a house where there has been fever or general bad health without any apparent cause, and you detect with your educated eye what is the matter. The soil pipe is not ventilated, or possibly the sink-stone is not disconnected; but unless you can prove to the magistrates, by the smoke or some other test of that kind, the leakage of sewer gas into the house, you are nowhere before the Court. We have had at times very clever evidence against us to prove that there was nothing the matter, and that there was nothing defective except perhaps the ventilation of the soil pipe. We could not satisfy the owners, therefore, except by the smoke test, and for the application of this we were prohibited from entering the premises. What we had to do then was to inject smoke into the public sewers, and so drive the smoke into the cupboards of the house, in some cases, where perhaps a pipe passed through, before we could convince the owners and the magistrates that we were right. It becomes very onerous if you have to take a course of that kind. You want a special surveyor and inspector before you can cope with such difficulties in a large town. There is the question as to granting certificates. Like Mr. Lemon, as a young man I thought I could do all kinds of things, and I very willingly, in Carlisle, did grant certificates after careful inspection of every new house; but

I have never yet, notwithstanding that we have a clear bye-law requiring the surveyor to grant them, granted a certificate at Leicester. I decline to give any certificate; it is probably not worth the paper it is written on three weeks after it is made out. I may give you an example from Leicester again, where we imagined we had looked pretty sharp after the builders in laying down the drains. The drain has been laid; the inspector is supposed, and can fairly say, that he has seen every pipe laid; he is perfectly satisfied in his own mind, as far as any inspection of that kind can be satisfactory, that that drain has been properly laid. Twelve months after there is a fever case in the house, then there is a second, then the inspector of nuisances is called in, and he cannot find any defect until the smoke test is applied, and when this is applied, and only then, he finds out what is the matter. The drain has been laid upon filled-up soil, the soil has settled, the joints are defective, and the sewage has found its way into the foundation of the house. That is the difficulty you have to deal with in the case of old clay pits. No supervision, not even the smoke test would have availed you in that case, and a certificate previously given in perfect good faith would have been taken as very good evidence, I imagine, against the surveyor. Mr. Newman raised the question of plans. He said the responsibility ought not to fall upon the local surveyor to have to give advice gratis to a landlord to show him how his drains should be laid in the case of old houses. There is a great deal of truth in that. On the other hand, while the landlord can secure the best services procurable in the town, on the part of the authority, by getting the surveyor to examine his house and tell him what is required to be done—and there is great objection to such a course—who is to do it if the local authority cannot be called upon to advise and act if necessary when a nuisance is complained of. I do not think, however, the duties of the local surveyor should go beyond this, when he is called upon to inspect a house said to be sanitarily defective, viz. to point out generally what ought to be done, and not make plans. His duty should stop there. If it is not the practice in Mr. Newman's borough, we have the power in Leicester to call upon the owner when he has received a sanitary order to put a house into a proper sanitary condition, to send in a proper and detailed plan to a scale 8 feet to the inch; and we do not allow anything to be done until the plan has been approved by the Plans Committee. Where you can exercise that power, you get over the

difficulty that Mr. Newman has raised in that respect; and I hope every borough surveyor can give us a similar experience. Mr. Newman also raises the question of well water. A surveyor may have very good grounds, on account of the well being in close proximity to a drain, to suppose it is unsafe to use the water of such a well; but he can do absolutely nothing without an analysis by the medical officer or public analyst to prove the water to be affected and injurious to health. I think with one of the speakers that the medical officers in certain cases have asserted a power they have no right to. I believe the province of the medical officer, at any rate on engineering matters or sanitary details, is to consult with the surveyor, and that they should consult with each other. I have no doubt there are many cases where the surveyor has allowed the medical officer to usurp some of his duties, where the latter has undertaken to direct what many sanitary details should be. The case given of the disconnection of a scullery sink-stone, where the work was so done that the defective drain, passing under the kitchen floor, was allowed to remain so that the sewage went its old course, as before the disconnection, proved the case against the medical officer being likely to get wrong if he acts in structural works without the surveyor. I could give you a much more striking case than this, but as the surveyor for the town in question is not present, who could tell you the tale in a much more drastic manner, I will not further refer to it than to say that it would only show that medical officers should not assume the functions of the engineer, and that the proper province of both is to work together for the common good.

The PRESIDENT: The discussion has shown that the Public Health Act is not so complete an Act as to deal with all these matters without great contention arising. Here we have had only seven or eight sections brought before us, and the discussion shows how deficient is the Public Health Act. On the question of certificates, I should like to say something. There is a clause here at Portsmouth in our bye-laws, that certificates should be granted, but that has never been carried out, and very wisely and properly. I believe that any such certificate would be to give a false security to the occupants of the house. The best certificate they could have would be the knowledge of some of the minor details of sanitary matters, and then they would not be gulled into taking houses that are unsanitary. With regard to the Medical Officer of Health and the Surveyor, they can work together, and work

amicably, for the public whom they serve. I think the point as to the water supply to a closet is one which certainly requires some considerable discussion. The opinion universally held is that you cannot compel a water supply, unless you can show a nuisance is existing. You can only then compel the occupier to abate that nuisance by throwing buckets of water, and cannot compel the owner to alter the apparatus or furnish a water supply.

The vote of thanks having been accorded with acclamation,

Mr. NEWMAN, in acknowledgment, said: I thank you very much for the vote of thanks for the paper, and I have been much interested in the discussion that has taken place upon it. There is one matter Mr. Gordon has referred to, which I think bears out my own ideas as enunciated in this paper; that in his borough they require owners of property, before altering drains, to deposit a plan of the alterations; but I do not think, under the Public Health Act, we have any power to require it. With reference to Mr. Clark's arguments that too much detail should not be given on matters of drainage, I quite agree with them; but what I want to see is, that the question of dealing with old drains should be on the same footing as the drainage of new houses, and I think it is unsatisfactory to have to go before magistrates, and for them to be the judges of what is required. It seems to me that the authority, as advised by their surveyor, ought to be the judges, and if the owners consider themselves aggrieved, they ought to have to go to the Local Government Board. With regard to water-closets, there is a case quite recently, where an authority, on the report of the Surveyor, gave notice to the owners, requiring them to construct one. The owners failed to do it, and the authority then constructed it. The authority sued for the cost, and got judgment, which was appealed against, and the judgment was confirmed. It is a comparatively recent judgment, within two years, I think; but I will send the Secretary the case. With reference to certificates, I am very much at one with all who have spoken on the subject; but I want to point out, inasmuch as the efficient laying of a house drain can best be judged during progress, I think the owners are entitled to a certificate that it has been inspected during progress. The smoke test may be afterwards applied and will detect leaky joints, but it is impossible after completion to ascertain that it is regularly laid unless the whole length is opened. On that account I think it is desirable a certificate to that effect should be given. I will send also the Secretary the name of a case which I think has settled

the question of private profit. The fact that it was a more economical way of draining a house cannot be construed into "private profit." I think I ought to add, it might appear that I am not in perfect harmony with my own medical officer of Health. That is not the case. My object in alluding to this matter was, not to bring any charge against the medical officer, but to state my opinion, that the correction of structural sanitary defects in existing buildings is more likely to be satisfactorily executed, if the amendment is required to be done by the surveyor, than if required by the medical officer.

PORTLAND CEMENT.

By W. SANTO CRIMP, Assoc. M. Inst. C.E., F.G.S., &c.

In submitting this paper to the Association of Municipal and Sanitary Engineers and Surveyors, the author has a twofold object in view: first to bring before its members a brief review of the methods by which two very commonplace materials, chalk and clay, are converted into that indispensable article Portland Cement; and second, with the assistance of the members, to frame a specification which shall ensure to the engineer a reliable cement, without unduly harrassing the manufacturer with unnecessary, and, indeed, as occasionally occurs, impracticable conditions.

Much has been written concerning Portland Cement, and many thousands of experiments have been made and the results published, by Messrs. Grant, Faija, Reid, and others; indeed, the 'Minutes of the Proceedings of the Institution of Civil Engineers' teem with papers and articles on the subject. The author feels, therefore, that in preparing this paper originality is impossible, all that he can do is to endeavour to describe the process of manufacture as seen by him in visiting various cement works, and possibly to bring some facts before the meeting that are new to at least a few of the members of this Association.

The earliest works established in this country for the manufacture of true Portland cement were those of Maude, Jones and Aspdin; Robins, Aspdin, & Co.; and J. Bazley White and Co., all established between the years 1825–44. Aspdin, whose name is associated with the two first-named firms, was the son of Aspdin, the Leeds bricklayer, whose patent, No. 5,022 of the 21st October, 1824, is the first in which "Portland Cement" is mentioned. Messrs. Scott & Redgrave state, however, that Aspdin's method of manufacture differs in many particulars from that now pursued.*

In describing the system of manufacture now in operation, the author will commence with the—

Materials.—On the banks of the Thames and the Medway,

* 'Minutes of Proceedings Inst. C.E.,' vol. lxii. p. 67.

where by far the largest quantities of Portland cement are manufactured, chalk, from either the upper or lower formations, is used in conjunction with gault clay, or with mud taken from the Medway known as "Gillingham mud," or with both clay and mud. At Bridgwater, Poole, Rugby, Stockton, and other places, lias limestone is used instead of chalk.

Proportions.—The proportions of clay and chalk or other limestone to be used in making the mixture known as "slip," varies with their nature. The object to be attained is the production of a mixture containing from 72 to 77 per cent. of carbonate of lime. White upper chalk is nearly pure carbonate of lime, being composed of upwards of 98 per cent. of that material,* while lower or grey chalk sometimes contains as little as 83 per cent.,† the remainder being principally clay; hence, at a large cement manufactory on the Thames, where white chalk only is used, 30 per cent. of clay is added, whilst at a works on the Medway, where the strong grey chalk is found, about 20 per cent. only of clay is required. An excess of lime produces a heavy cement when very highly burnt, but not one of a reliable nature, since the excess of lime requires to be air-slaked, by being exposed in thin layers, before the cement can be used to advantage, otherwise it is liable to "blow" in the work; it is, however, quite possible in such a case to "air-slake" until the cement becomes dead and nearly valueless. Such cement will not stand the tests to be discussed later on. For builders' work, such as rough cast stucco, &c., a very suitable cement is produced from a mixture containing from 70 to 72 per cent. of lime; being more lightly burnt, it grinds easily and sets rather quickly. This is not, however, an engineer's cement, being deficient in cohesive properties when tested with sand.

Manipulation.—Having decided upon the most suitable proportions of clay and chalk, or other limestone, the material should be carefully weighed before being tipped into the wash-mill. At the best works, each truckload is weighed and the contents adjusted to the standard. Wash-mills are constructed in various sizes up to 28 feet in diameter. A circular excavation is made, and the sides and bottom are lined with brickwork. A pier is constructed in the centre for the purpose of carrying the shaft, which is placed vertically; radial arms are fixed near the bottom of the shaft, and

* Schweitzer. † Col. Scott, R.E.

from these heavy harrows depend. Framework of a suitable nature, with bevil gearing, forms the upper part of the mill, and, power being provided, the harrows rotate at a rapid rate, for the purpose of breaking up and mixing the chalk and clay, sufficient water being added to form a stiff paste, technically known as "slip" or "slurry." Formerly large quantities of water were used—as much as 200 per cent.—the resultant mixture, being in an extremely liquid state, gravitated to rectangular brick tanks, termed "backs," where the excess of water was drawn off the top, as the solids settled. When sufficiently solidified, the material was placed on the drying-floors, to be described later on. There were many defects in this method, the principal one from the engineer's point of view was that, in flowing into the settling tanks, the homogeneity of the mixture was destroyed, as particles having the greatest specific gravity soonest fell to the bottom, thus the mass at its point of entry into the tank was quite different from that at remote points, and consisted largely of sand. In wheeling the partly dried material to the drying floors, in spite of the special instructions to the labourers, the admixture was very imperfectly effected, with the result that the sandy slip, when placed in the kilns, fused, forming an inert glassy clinker. The smallest quantity of water consistent with utility is now used in the wash mill, the "slurry" being a thick mobile paste. From the mill it passes to a pump well, where slow-acting plunger pumps force it to a height sufficient to command the wet grinding mills, consisting of French burr stones, or heavy edge-runner mortar mills; in passing through the mill the attrition of the harder particles is effected, and the mass is thoroughly and evenly mixed. After being screened, the prepared "slip" is conducted in iron mains to the various drying floors. Mr. Michele has introduced an iron wet-grinding mill (of which the small sewage liming machine made by Messrs. Bowes-Scott and Read, is a model), which gives satisfactory results. The great object to be accomplished is the complete pulverisation of the chalk and clay, and their thorough admixture, together with the interception of recalcitrant foreign substances.

Drying and Burning.—There are many different kinds of combined kilns and drying floors. The object of the manufacturers is the utilisation of as large a proportion of heat from the kilns as possible in drying the "slip," in order to reduce the cost of production, together with the thorough calcination of the contents of the kiln; its best form is, therefore, more a question for him than

for the engineer. The old form is shaped inside like a soda-water-bottle, and is charged with about 90 cubic yards of dried "slip" and coke, yielding about 30 tons of clinker, while the newer forms are of about half the capacity, and of various sections. The drying of the "slip" is effected by passing the products of combustion from the kilns either under, over, or both under and over, the drying floors on which the wet "slip" is deposited. In the preparation of the "slip" about 35 to 40 per cent. of water is now used under the "Goreham" or "stiff" method, as against 200, or even a larger percentage under the old system, the chief defects in which have been pointed out. In order to convert the dried "slip"—which now contains about 10 per cent. of moisture—into clinker, the kiln is charged with coke and "slip" in alternate layers of about 4 inches and 8 inches respectively. In the "Goreham" system, 35 to 38 tons of coke are used in the production of 100 tons of clinker, this including the drying of the "slip" as well as its calcination. Under the old or wet process, according to Mr. Johnson, about 15 per cent. more fuel is required.* The small kilns are drawn on the third or fourth day after the charge is fired, while the larger kiln requires a week for the conversion of its contents. When sufficiently cool, the mass of clinker is broken down and conveyed to the mills. On the removal of the clinker, it will often be found that some of it, where in contact with the sides of the kiln, has become vitreous, the fire-brick lining providing a flux; this should be picked out, as it will grind into a useless inert substance. The topmost layer, of a thickness of 6 to 9 inches, is imperfectly calcined and is of a light colour and readily crumbles. This contains much free lime, and if mixed and ground with the good clinker will produce cement of inferior quality, being hot and liable to blow. All such under-burnt clinker, should therefore be carefully picked out from the hard, well-burnt clinker, when a first class cement is required. The author has kept a piece of this kind of clinker in his office for some months by the side of a piece of very highly burnt clinker of good quality; no change in the latter has taken place, but the former commenced to crumble after an interval of about six months, and then rapidly disintegrated, in consequence of the air-slaking of the large proportion of free lime. Such cement would undoubtedly expand when used in the construction of works, and possibly lead to disastrous results.

* 'Minutes of Proceedings Inst. C.E.,' vol. xlii. p. 76.

Grinding.—The reduction of the clinker to the impalpable powder known as Portland Cement, is effected by means of Blake's crushers, or by steel rollers, or other means, in conjunction with French burr millstones. On passing through the crusher, the partially-reduced product is carried on endless bands, or by Jacob's ladders, or other contrivance, to the mills, where it is ground in a similar manner to flour. A pair of stones will grind about 1¼ ton per hour. In the best works, the hoppers discharge their contents into a sifting machine. Mr. A. Glover, the able manager of Messrs. B. White's works, has invented an admirable machine for the purpose, sieves with meshes of varying degrees of fineness being readily inserted in order to comply with the different specifications. A simple device prevents the sieves from clogging. The sifted material is taken to the storing sheds, where it is put up in casks or bags, in the form with which we are all familiar. The coarse particles are returned to the mill, and are re-ground, and should produce the very best cement. The importance of reducing the particles to an extremely small size cannot be over-rated. The experiments of Mr. Grant and others are conclusive on this point.

Testing.—Specifications for cement generally contain three provisions, referring to:—

1. The degree of fineness.
2. The weight per bushel.
3. The tensile strength.

1. Now the excellence of Portland Cement, may be judged almost entirely by its power of cementing together particles of sand, and it has been conclusively proved that the finer cement is ground, the more highly this property is developed. Take for example a cement of a common specification, where 80 per cent. must pass through a sieve having 2500 meshes to the inch; on testing the particles retained by the sieve, it will be found that they possess no cementitious properties whatever, while if an equal proportion of clean sharp sand be mixed with the sifted cement, the mixture will be as strong as the cement was in its original condition; such cement may therefore be said to be adulterated to the extent of 20 per cent. with clinker. Now take a cement, 90 per cent. of which must pass through a sieve with 5800 meshes to the square inch; the retained particles will be nearly as valueless as before, but the cement will, in addition to being finer generally, be adulterated to the extent of 10 per cent. only. In cases where cement which passed through a

sieve of 32,257 meshes to the square inch has been subsequently mixed with three parts of sand, and tested, its strength, compared with the same cement when sifted so as to pass 90 per cent. through a sieve of 2580 meshes to the square inch, has been found to be 41 per cent. greater, the briquettes being broken 25 weeks after being made.* When tested neat, however, the coarser cement was much the stronger; thus the importance of testing with sand is apparent. In Mr. Grant's experiments, the access of strength in cement passed through 5800 to the inch, when compared with the same cement passed through 2500, was found to be about 17 per cent. when mixed with three parts of sand;† a further confirmation of the importance of fine grinding. The author is of opinion that, as a standard of fineness, 90 per cent. should pass a sieve of 5800 to the square inch.

2. With regard to a standard of weight. With the introduction of the sand test, the question of the weight per bushel is of minor importance. If a weight is specified, it must be remembered that the more finely cement is ground, the greater will be the space occupied by a given weight; hence a very finely-ground cement is lighter, bulk for bulk, than the same cement coarsely ground. A weight of 112 lbs. per bushel, when the measure is filled lightly in the orthodox manner, will be found to be a very good standard with cement of the fineness suggested. If a one-tenth of a bushel measure is used, its contents should weigh 10·5 lbs., since in the smaller measure the material is not so much compressed.

3. The tensile strength of cement is ascertained by making briquettes of the material in specially constructed moulds, and, after immersion in water for certain periods, fracturing them in specially designed machines. The testing may be carried out with great nicety in a laboratory provided with a great variety of special appliances. The tests of the engineer, however, must be readily applied, and a sieve of 5800 to the inch, weights and scales, one-tenth of a bushel measure, testing machine and moulds, together with a few commonplace appliances, are all that are necessary. The best mould is that which forms a briquette shaped like two frustums of a wedge joined at the small ends, the sectional area at the weakest part being one square inch. In applying the weight, the strain should not be exerted at a more rapid rate than that of 100 pounds in 15 seconds, since higher or lower breaking strains

* Grant, 'Minutes of Proceedings Inst. C.E.,' vol. lxii. p. 149.

† Ibid, p. 174.

will be registered if the rate be faster or slower, and uniformity can only be obtained by using like methods. If the specific gravity is also made a condition of the specification, it should be about 3·10.

The admixture of sand with the cement to be tested, now known as the "sand test," was first adopted in Germany; and since its introduction into this country there can be no doubt that where fine grinding has been a condition of the specification, the cementitious power of Portland Cement has been much increased, in consequence of its greater fineness, compared with the ordinary cement of commerce. Although the neat test is in some respects useful, it cannot be denied that, as cement is generally used in combination with sand or gravel, its true value can be known only when it is mixed with these substances before being tested. The chief difficulty lies in the fact that sands alike to the eye, even when placed under the microscope, give widely different results. It is necessary, therefore, that the sand used should be identical in every characteristic, if perfectly accurate comparative results are to be obtained. Sands vary in weight, as well as in other properties, and as the standard test consists in adding three parts by weight of sand to one part of cement, the bulk of sand will of course vary with its weight. The author procured some crushed Leicester granite of the standard size, namely that passing a sieve of 20 meshes to the lineal inch, but retained on one of 30, and some standard sand from Heath, near Leighton Buzzard, with the result that crushed Mount Sorrel granite weighed 97 lbs. per bushel; standard sand, Leighton Buzzard, 122 lbs. per bushel. In bulk, therefore, equal weights of these sands differ to the extent of 20 per cent., since 97 lbs. of standard sand would only occupy 80 per cent. of a bushel measure. The necessity of using sand from the same pit for testing is therefore all the more obvious.

It is frequently urged that in carrying out works, sufficient time cannot be allowed for the sand-testing of cement. In small works this is often true, but the difficulty might in most cases be overcome by the local and municipal authorities providing a cement store, and purchasing direct from the manufacturers the cement required for their small contracts. The cement could be procured on their deciding to carry out the works, as an interval of a month or six weeks is usually occupied in advertising, preparing the contract, and other preliminaries. A clause might then be inserted in the specification to the effect that the contractor would be supplied

with all the cement required, at a stated price per ton. In this way a useful check upon dishonesty would be exercised, as the exact quantity required would be known to the surveyor; and it is certain that good cement would be used in the work.

We next have to consider the question of a standard specification, but before doing so it will be useful to further consider the question of fineness of grinding.

Experiment will prove that in cement to the ordinary specification of 80 per cent. to pass a 2500 sieve, about 23 per cent. will be retained on a sieve of 5800 to the inch, and that this residue possesses no cementitious properties. Such a cement may be purchased alongside the London wharves at about 28*s*. per ton. But obviously as we have but 77 per cent. of useful material, and 23 per cent. of clinker, which we may value at 2*s*. per ton—the price of sand—the cement really costs much more. For instance if we buy 100 tons we pay 140*l*. for it:—

	£	*s*.	*d*.
The 23 tons of clinker at 2*s*.	2	6	0
The 77 tons of cement at 35*s*. 9*d*.	137	12	9
	£139	18	9

so that, omitting small fractions, the cement really costs 1*l*. 15*s*. 9*d*. per ton.

Now cement, ground to pass 90 per cent. through a 5800 mesh sieve, may be purchased at 33*s*. per ton, and 100 tons will cost 165*l*.:—

	£	*s*.	*d*.
The 10 tons of clinker at 2*s*.	1	0	0
The 90 tons of cement at 36*s*. 5*d*.	163	17	6
	£164	17	6

so that an apparent increase in price of 5*s*. per ton, really is not more than 8*d*. per ton. It is also obvious that as we have more cement proper in the finely-ground article, we may use more sand in making mortar with it. In some experiments which the author made with standard sand and cement, he found that the quantities of mortar produced with varying proportions of cement were as follow:—

1 volume sand,	1	volume cement	made	1·5	volumes mortar
1 „ „	2	volumes	„	„	2·4	„ „
1 „ „	2½	„	„	„	2·85	„ „
1 „ „	3	„	„	„	3·33	„ „
1 „ „	4	„	„	„	4·30	„ „

Now suppose we desire to make mortar with cement to the No. 1 specification in the proportion of 1 of cement to 2 of sand. The ingredients are—sand, cement, and clinker. The cubic yard (21·04 bushels) is a convenient measure of volumes:—

	£	s.	d.
2 cubic yards of sand at 2s. 3d.	0	4	6
6 cubic feet of clinker at 1d.	0	0	6
21 cubic feet of cement at 1s. $4\frac{7}{10}$d.	1	9	3
Total	£1	14	3

The product will be 2·4 cubic yards of mortar, costing 14s. 3d. per cubic yard, exclusive of the labour of mixing. Here we have 21 volumes of cement to 60 volumes of clinker and sand, or 35 per cent.

Now in the second case we will take 1 yard of the finely-ground cement and 2½ yards of sand, costing:—

	£	s.	d.
2½ cubic yards of sand at 2s. 3d.	0	5	7½
2·7 cubic feet of clinker at 1d.	0	0	1½
24·3 cubic feet of cement at 1s. 5d.	1	14	5
	£2	0	2

The product will be 2·85 cubic yards of mortar, costing 14s. 1d. per cubic yard, and we have 24·3 volumes of cement to 71 volumes of sand and clinker, or 34·22 per cent., so that, as a matter of fact, we may use the more finely-ground cement with a larger volume of sand, and produce a mortar costing practically the same, whilst we may be quite sure that, with the sand test, the finely-ground cement will be both safer and better.

In suggesting the following specification, the author feels that as Town Surveyors are among the largest consumers of cement in this country, uniformity of quality for the cement used by them is desirable, as tending to the production of high-class work, and as providing the makers of cement with a guide, which, without unduly harrassing them, shall enable them to turn out a cement of really good and uniform quality. If all specifications were alike, the manufacture of the article would be simplified, and better results would accrue.

Suggested Specification.

Weight.—112 pounds per Imperial bushel.

Specific Gravity.—3·10.

Setting.—Time of setting at least 1 hour.

Expansion.—Thin pat samples to be made up on glass, and to be kept moist for 24 hours, then half are to be immersed in water, and, after the expiration of 48 hours, cracks are not to be apparent in any of the samples.

Grinding.—90 per cent. of every sample tested is to pass through a sieve having 5800 meshes per square inch. The wire for the sieve to be No. 36 B.W.G.

Sand.—The sand for testing is to be perfectly clean Leighton Buzzard, only that passing through a sieve of 400 meshes per square inch, but being retained on one of 900 meshes per square inch, being used. The wire for the sieves to be No. 33 and No. 34 B.W.G. respectively.

Neat Tests.—The cement when tested neat, mixed with about 20 per cent. of water, shall be capable of sustaining a tensile strain of 480 pounds per square inch, seven days after being made into briquettes, during the last six days of which the briquettes have been immersed in water. At the expiration of 28 days, the briquettes shall be capable of bearing a tensile strain of 600 pounds per square inch, having been immersed in water during the last 27 days.

Sand Tests.—One part by weight of cement and three parts by weight of standard sand are to be mixed with about 10 per cent. of water, the whole to be well mixed for 5 minutes, and then to be well beaten into the mould with a light spatula for 1 minute. The briquettes are to be placed in a shallow zinc-lined tray, and covered with a moist cloth for 24 hours, after which they are to be totally immersed in water for 27 days; the briquettes are then to be broken, and the average tensile strain to be sustained by ten briquettes shall not be less than 225 lbs. per square inch.

Testing.—The strain is to be applied at the rate of 100 pounds in 15 seconds. In all cases the mean of ten tests are to be taken as being conclusive.

DISCUSSION.

Mr. T. de C. Meade: I have much pleasure in moving a vote of thanks to Mr. Crimp for this very able paper. It is most interesting to us all, and to me particularly, because I have been regularly testing cement for the past nine years. I find his specification very near to what I have been using for the last two years. I used to specify a cement to pass through a sieve of 3600 meshes to the square inch, with a residue not exceeding 10 per cent. and a tensile strain of 350 on an inch section. We gradually got it up until, two years ago, the cement we used conformed to the following specification, viz. 5800 meshes to the square inch, with a residue not exceeding 10 per cent., tensile strength 420 lbs. to the inch section, and weight 112 lbs. per bushel. In practice I find the weight of the cement slightly exceeds 112 lbs.—it generally weighs 114 lbs., but much depends on the manner of filling the measure. In making the briquettes they should not be beaten into the mould. Now that is a very important thing. The percentage on the tensile strain is more affected by that beating into the mould than perhaps any gentleman here imagines. I use a small trowel, specially made, and a quantity of water not exceeding 25 per cent. With some cement it is difficult to get it to work with less water. There is a way, with the exercise of some little skill, by which it may be worked with less water, and I do not think I should be overstating it in saying that I could get 10 to 15 per cent. better results in the tensile strength. There should be uniformity in all cases. I find that by specifying not less than 20 and not more than 25 per cent. by weight of water, you get something approaching uniformity. On one occasion, a gentleman came to my office from a cement works, to show what he could do in mixing cement almost dry, and he did succeed in getting results from his cement that were really very surprising. The results were obtained by ramming in the cement with the trowel handle and a square piece of wood. I think the principal thing to aim at is to get uniformity in every case, not to test with sand in one case, and with neat cement in another. This ramming business, with nine men out of ten, will be a failure. We want to get something that will pass a certain standard, and we do not want to put a specification before the makers that they cannot conform to. I have no difficulty in getting a cement to exceed the specification I have mentioned, viz. of 5800 meshes to the square inch, a residue not

exceeding 10 per cent., and a tensile strain of 480 lbs. to the square inch; but in most cases it weighs slightly in excess of the 112 lbs. Although the sand and cement tests are instructive, I object to specify them, because of the difficulty in getting the sand at all times of uniform quality.

Mr. Ellice-Clark: It is desirable that uniformity in regard to cement should be obtained if possible. The German engineers have for a long time recognised this point. One of the great manufacturers of this country told me he was making twenty different kinds of cement—at least he had twenty different specifications to work to—and if it would be possible to compare notes and agree on some tests, it would be satisfactory. It is said on good authority that although the Metropolitan Board of Works specified cement ground to exceeding fineness, it was found impracticable upon their large works to get cement ground so fine as their specifications mentioned, and it was the habit of their engineers to allow a greater quantity of cement to be used, and a lesser quantity of aggregate, to make up for the coarser cement than was specified. When we built the sea wall at Hove, we should have had very great difficulty in obtaining a cement such as specified by Mr. Crimp. We there used a cement which left a residue of 10 per cent. on the 2,500 sieve. In 1872 I built the sea wall at Ramsgate, where the action of the sea has been constantly on the cement joints. I was over those works the other day, and the cement in all the joints is in magnificent order; nothing could be better. I am inclined to think fine grinding has been pushed to an extreme limit. Of course with a very finely-ground cement, you cannot get a high standard of weight. With a moderately fine ground cement, having a residue of 10 per cent. on the 2500 sieve, and a weight of 114 lbs., taking care that the cement has been laid out and turned over so as to aerate it, you are likely to get a cement which will do engineers credit.

Mr. Gordon: This paper is one of very great interest to myself, but under the conditions we are labouring this afternoon, having so much work to do, it would be impossible for me to give you my experience with cement. I have there on the table a bundle which would occupy much longer time than can be allotted to me, but it may be of interest to you to know that the reference that has been made to the sand test was introduced by myself in Germany in 1867. At that time the German manufacturers were far behind the English, and it was because

I was besieged by manufacturers, in starting the works at Frankfort, to take their cement, and that this, that, and the other manufacturer had a reputation, that I said to them "Your reputations are most likely all right, but I begin *de novo* here." I began the sand test of three to one, which has prevailed throughout the country since, and was, I believe, shortly afterwards introduced more generally into England. I have continued to use that test up to the present day. I regret to say that I cannot agree with Mr. Meade that a uniform test is only to be obtained by testing the pure cement; I think that is a mistake. You must test, in my opinion, pure cement concurrently with sand mixed with it. Every cement brought before me is tested on these lines. I have tested them one to one, and two, three, and four to one, and I have found that a cement which was of equal quality with another as pure cement, when you applied the test of sand, and the same quality of sand, equal tensile strains were obtainable from one of these cements with a mixture of four of sand, as against the other with only three of sand. That proves there was something about one of the cements, which though of equal quality with another as pure cement, greatly enhanced its value when mixed with sand. I had continuous tests made for seven and a half years in Germany, and the number of tests during that time were about 22,000. During the last four years I have continued similar tests, and while I approve generally of the specification set up by Mr. Crimp, I think he will find that he is setting up too high a standard, and that it will be practically impossible for manufacturers to comply on a large scale with such a test. The more the cement is calcined no doubt the better, but you cannot get it of this quality in the large quantities required for large works. The sand test of 225 per square inch in 27 days is too high for general work. I will not say more now, because it is a subject on which I could say a great deal, and give you many results, were it not out of place on the present occasion. I am especially pleased with one thing in the paper. On page 9 the author has given you a statement of the quantity of mortar produced by the mixture of one volume of sand with one of cement, and so on up to four. I could supplement that test, carrying it up even to fifteen. It is by such tests as these that you have the advantage of knowing what kinds of concrete may be used to work economically for your Corporation. If the engineer has large cement concrete works in hand, and is not well up in these points, he may waste a good deal of money. I am ex-

ceedingly pleased we have had a short paper from Mr. Crimp of such value, but it is a paper which will bear supplementing and carrying further on some future occasion. For the satisfaction of Mr. Santo Crimp I should like to state that the whole of the works I carried out on the Continent were on the principle advocated by Mr. Crimp, and that we contracted for the cement and supplied it to the building contractors.

Mr. Angell: I have been a very large user of concrete, and I have made large concrete sewers, and have had many conversations with the late Mr. Grant thereon; the difficulty I have met with is, not only to get the makers to work up to the test, but to get it in sufficient quantity. For the sand test you require it at least a month in advance, and if the contractors do not keep up stock what are you to do? You have to fall back upon the seven days' neat cement test. Then the local cement manufacturers want to know why their cement will not suit, and regard your tests as those of a faddy engineer, and altogether an unpractical idea. Locally, in towns you have very great difficulty in working up to the standard. I would urge all present to have their cement properly up to the standard, and disregard those merchants who will not work up to the test. A weight of 112 per bushel is somewhat lower than I should be prepared to accept. The suggestion in the paper to purchase your own cement is a very good one, but, I think, difficult to carry out under our present system of contracting.

The President: The best way out of the difficulty would be for corporations to lay in a large stock of cement for themselves. I think it is right we should have a uniform standard specification for cement, which might either emanate from ourselves or from the Institution of Civil Engineers. It would obviate the very great difficulty we have now in preparing specifications for our contracts.

The thanks of the meeting having been voted with acclamation,

Mr. W. Santo Crimp, in reply, said: I thank you very much for the kind way in which you have received this paper. This is the fourth time I have had the pleasure of submitting papers to this Association, but it is the first occasion on which I have had the honour of reading a paper, as, unfortunately, I have hitherto been unable to attend the annual meeting. Most of the gentlemen who have spoken agree that uniformity as regards specifications for Portland cement is desirable. I see, in the course of a year, a great number of specifications, and unless I were to make extracts

from them, and submit such extracts to the meeting, members would not believe that such rubbish could be written. Unfortunately, the writers will not be reached by this paper, as I am quite sure they are not members of the Association. It is simply impossible for the cement manufacturers to comply with one-half the conditions found in these specifications. Mr. Lewis Angell said we could not get the cement to the suggested specification in quantity sufficient for large contracts. It cannot always be procured, for the simple reason that manufacturers are making cement to perhaps twenty different specifications; but if all specifications were alike, or nearly so, as much cement could be made as under existing conditions, and, as a consequence, we should all get the cement we required. I am glad to say we have no local merchants in Wimbledon whose influence with my Board is greater than mine, and I think surveyors are often to blame themselves if such conditions prevail. With regard to the weight of cement per bushel, it appears to be thought that 112 lbs. is too light; but I take that weight in conjunction with the other tests, and I submit that with this specification you will have no difficulty in getting a cement weighing 112 lbs. to the bushel. Of course, with regard to the sand test, you may make it or leave it alone; there is a neat test preceding the sand test, and if your cement meets that, I have no doubt it will be a good cement; but the neat test cannot be as reliable as the sand test, for the reasons mentioned in the paper. In drawing up the suggested specification I have had the advantage of consulting one or two manufacturers, and they concur in saying they would rather work to that specification than to the twenty different ones to which they are working now.

SEWER VENTILATION.

By ARCHIBALD H. FORD, A.M.I.C.E.,
Consulting Engineer to the Fareham Union Rural Sanitary Authority.

Although, no doubt, the question of sewer ventilation has been ably brought before you at several previous meetings of your Association, yet I think you will agree that no perfectly satisfactory solution of the problem has yet been reached, and that there is scope for further investigation in regard to this matter, which is of so much importance as affecting the public health.

Whatever opinions may be held by medical and other scientific men, as to the action of sewer air, in causing typhoid fever and other diseases (and opinions differ), it is, I think, almost *universally conceded,* that sewer air, by infecting food or drink, or when continuously inhaled, does produce much dreaded diseases.

Sewer air (or, as I have seen it called, "aerial sewage") and typhoid fever, are so associated in the public mind as cause and effect, that it may sometimes possibly happen that epidemics, or individual cases of disease, are attributed to defective sewers or drains, or to their imperfect ventilation, when the actual cause might be found in some other direction; but these are points for medical and chemical experts to determine, it is sufficient for engineers to know, that sewer air is dangerous to health, and to life, and often exceedingly offensive to the sense of smell, under our existing systems of ventilation; to secure, that every proposed remedial measure, shall receive at their hands the most full and impartial consideration. The evils resulting from imperfectly ventilated sewers have been known from the days of the Romans (as evidenced by their works), and are now so universally recognised, and indeed dreaded, that I shall not venture to occupy your time by enlarging upon the consideration of this part of the subject.

The beneficial effect of diluting sewer air with cool fresh air, will probably not be questioned. Experienced analysts, tell us that free and uncombined oxygen, invariably present in natural waters, is practically absent in sewage, and that an excess of nitrogen is

found in the air of sewers, the oxygen having been consumed by acting upon the organic pollutions.

Attempts have therefore very naturally been made from time to time, to secure the dilution of the sewer gas in the sewers, by creating continuous and regular currents of fresh air along them, but hitherto without any marked success, owing chiefly, in my opinion, to the retarding forces at work within sewers, viz., the friction of the sewage current on the air, the expansion and contraction of the air by constant changes of temperature, owing to the entrance of hot and cold liquids, and also to the varying ebb and flow of the sewage.

What I have to suggest for your especial consideration and discussion to-day, is the feasibility of overcoming the retarding influences to the free dilution of air in sewers, and the creation of continuous and regular air currents, for their ventilation, by providing sewers, with a *special, partially disjointed or disconnected air passage*, as shown by the diagrams and specimen pipes which are now before you, and which special air passage I may at once say is the subject of recent patents in this, and foreign countries by myself and Mr. E. G. Wright of this town.

By this arrangement, we claim to be able to obviate the objectionable and imperfect system, which is at present almost universally resorted to, of permitting the undiluted foul gases from sewers to discharge at road surfaces, the ventilation on our system, being secured by means of the air passage, in conjunction with a downcast and upcast shaft and a current of fresh external air, which, in the application of the system to sewers, we advocate should be forced into the air passage, so that, under pressure, part of the air escapes from the air passage into the sewer, through those openings in the former which are nearest the downtake shaft, rendering the air at that end of the sewer cooler, and therefore heavier, than at the other end, near the uptake shaft, thus continually forcing the lighter and warmer air into the air passage, and expelling the diluted sewer air through the uptake shaft, into the open air above the roofs of buildings.

You will see by the diagrams and ventilating pipes, that the air passage is small compared with the sewer, and you will realise that by resort to the special air passage, not only is the friction of the sewage flow on the air currents obviated, but that sudden expansions and contractions of the air which take place in the sewer, would have a considerably less effect in the air passage than

in the sewer, and consequently, that a current of fresh air can be secured and brought under control in the air passage, as to its direction, without resort to any considerable force, which we consider a very important and self-evident advantage; and which also renders available a simple and economical method of creating a current, and forcing in fresh air, by means of jets of water, acting in the down-take shaft; which I will presently describe.

It has been held by high authorities, that to overcome the retarding forces at work in a sewer, a current of such great velocity would be required, as would imperil the water seals of the traps of adjoining house drains. We claim that by resort to a special air way not only is the force required to create the air current reduced, but the risk, with reference to the traps is obviated, as the force of the air current is confined to the air passage, which, being at the top of the sewer, is not connected with the branch drains or house connections, the movement of the air in the sewer itself, being secured by the arrangement of openings in the air passage, which is thus made to act as a fresh air distributor all along the sewer, the gases not being able to escape before they pass into the air passage, and become diluted with the fresh atmospheric air, while stagnation, and accumulation of foul gases is rendered impossible.

Many eminent opinions might be quoted, condemnatory of the system of ventilation of sewers by openings in the road. I will content myself with quoting one, viz. Mr. Wm. Geo. Laws, Borough Engineer, of Newcastle, who, in a paper read at the Congress of the Sanitary Institute of Great Britain, in 1882, pointed out very clearly, and in a tone of sarcastic condemnation, which I think is excellent, the evils resulting from the open gratings at the manholes, and he said, " that as a means for securing that every person passing by, shall breathe the greatest possible amount of poisonous gas, this arrangement is almost perfect; but as an outcome of sanitary engineering effort it is depressing." Yes, as matters stand, it is indeed depressing, and engineers who are called upon to devise schemes of sewerage, commence their task with the knowledge that the exit of sewer air at the roadway, is considered by the most experienced members of the profession, as the best known means at our disposal, and the fact is forced upon us, that engineers of to-day, are little if at all in advance of those of fifty years ago upon this important question, which so closely affects the public health.

I will now refer to a paper read by Mr. B. S. Brundell, C.E., at Doncaster, in 1882, before a Northern Counties Association of

Medical Officers of Health, on the Ventilation of Sewers, in which it was advocated that it was not only necessary to provide vent, but to ensure also a current of fresh air, and that a constant interchange between the outer air and the sewer should be aimed at; he also advised that where there was a tendency for the gases to travel up the sewer, flap valves should be placed, so as to stop the upward current, and urged that main sewers should be systematically flushed.

Mr. Masters, in a paper read at the same meeting, on the "Circulation of Air in Sewers," expressed his opinion, that "the most effectual means of creating a good current of air in sewers, and ensuring the ventilation and thorough cleansing of the sewers, was by a constant stream through the whole length of the sewer (instead of an occasional one) at a velocity of not less than 3 feet per second."

"It had," he said, "been proved that air would follow a stream travelling at 2 feet per second, in preference to rising to the highest point of the sewer."

I fully concur in the desirability of securing a constant interchange of air between the sewer and the outer air, inside the sewer; but how this can be accomplished in a reliable and economical manner is an unsettled point with engineers. I submit, however, that the provision of a special air passage, such as I have described, can greatly help to solve the difficulty.

All engineers who are responsible for the proper working of a system of sewers will agree that efficient arrangements for the systematic flushing of the sewers is an essential adjunct to any system of sewer ventilation, and I question whether there is any better, or more ecconomical, way than by a much more general resort to the use of automatic flushing tanks, which we advocate should be provided in connection with our system, to utilise the water, by means of which we suggest that the fresh air can be first economically introduced.

The proposition that a constant stream of sewage should be maintained in sewers, sufficient to carry a stream of air with it, seems to me quite impracticable, owing to the ever varying fluctuation in the volume of sewage and the changing gradients; but it raises the question of the friction of the sewage flow upon the air currents, which I believe is a point that has not hitherto been sufficiently considered, as a practical difficulty to be overcome.

There can, I think, be no question that in a sewer of ordinary

construction, laid with such a fall, as would constitute a self-cleansing gradient when running even less than half-full, that the water drags the air current along with it; but when the volume and rapidity of the flow of sewage subsides, as it does in most sewers at night, and during many hours of the day, the air current is then reversed, and follows its natural course to the higher portion of the sewer, or sewerage system; thus the air currents travel first in one direction and then in another, and this friction of the sewage upon the air, much as it may facilitate a current of air in the direction of the sewage flow, constitutes a very disturbing element in every existing system of sewer ventilation.

Regularity of action is one of the first essentials to be secured, as inlets for fresh air into sewers, could be put anywhere so long as engineers could rely that they would under all conditions act as they are intended, while foul-air outlets can always be put in positions of safety, high up above the roofs of buildings, or in other positions above the atmospheric air we breathe.

The great desideratum seems to me to be, that after fixing the position of both fresh-air inlets, and foul-air outlets, with the best judgment under the particular circumstances, they shall act as designed, constantly and regularly; and I submit that by the provision of such a special air passage as I have described, this desirable result can be secured.

In submitting a proposal which provides for the ventilation of sewers by introducing fresh air, I must be permitted to quote the opinion of Dr. Angus Smith on "Air as a Sanitary Agent."

In an address at the Sanitary Congress in 1883, this eminent authority (although not confining his observations to sewers) said he "came to the conclusion that a current of air either carried away the organic matter with it, decomposing it and turning it into gases, or if it was not possible for the oxygen alone to do that, it might happen that the oxygen destroyed those minute forms, which had been shown to be concomitant with putrefaction and decay."

"A similar mode of thought had previously led him to consider that it was the want of that excess of oxygen that caused confined sewer gases to be so dangerous."

"As putrefaction seemed not to take place without the action of organisms, he had the idea that it might be arrested by an abundant use of air, and he had some belief that oxidisation took place very rapidly after putrefaction."

"They could scarcely doubt that putrefaction took place more rapidly when the organic matters were diluted to a very considerable extent with water; aeration not only prevented putrefaction, but prevented also the chemical action consequent on it. Nitrates were also more readily formed in aerated than in non-aerated specimens of sewage."

"If the oxygen was found to diminish the activity of those minute moving particles which formed or produced chicken cholera, as Pasteur had shown, and if oxygen also put an end to the decomposition of sewage in a manner rapid and decided, so that decomposition would not begin again for some two or three weeks, according to the weather, they might ask how far it might be used directly in the destruction or weakening of microbes in other situations."

That is a strong opinion in favour of the use of fresh air to destroy the effects of putrefaction. Sanitary engineers, are, however, fully alive to its oxidising powers, and have proved their faith in air as a sanitary agent, in dealing with sewers and sewage. In our sewage farms we know its marvellous effects, and even in the so-called ventilation of sewers, we rely upon air to counteract the baneful influence of the escaped sewer gases at the road grids; but I am of opinion, that what should be aimed at, is that this great sanitary agent, which nature provides everywhere in unstinted abundance around and about us, should be made to do its work systematically and surely inside the sewers, and not, as at present, after the dangerous gases have escaped at the road grids, or gulleys, under our very noses, to be breathed often, I doubt not, before the great sanitary agent, fresh air, has had time to perform its health-saving work.

If time had permitted, I should like to have referred in detail to some of the patents that have been granted in connection with the ventilation of sewers. Between 1867 and 1876 there were, I find, thirty-six relating to the subject, but as the abridgments of specifications from 1876 are not yet published, I cannot speak to the number since that date; judging, however, by the records in the professional papers, they have been numerous.

Excluding those which proposed passing the air through charcoal, the preponderating idea with the majority of the inventors has been in the direction of creating air currents in the sewer, and diluting the sewer air, but very few of them seem to have known or realised, what Sir Joseph Bazalgette reported with regard to the experiments in 1858, on the sewers near the furnace of the clock-

tower of the House of Commons, viz. "that there exist in sewers velocities amounting to 100 feet per minute and upwards," owing to the forces to which I have previously referred; or the opinion of Colonel Haywood, speaking on the same subject, viz. "That a downdraught so complete as to be superior to the diffusive power of gases, you cannot start with a velocity of less than two miles an hour."

The Chelsea Vestry in 1888, experimented on a sewer in their district by means of downdraughts from cowls, on a system patented by Mr. Harrington, which dispensed with the road ventilators; and although the recorded results vary, as might be expected, according to the force of the wind, the beneficial effects of diluting the sewer air with currents of fresh air, were, I think, fully demonstrated.

Mr. Strachan, the Surveyor to the Vestry, who took the observations himself, observes in a paper recorded in the Minutes of the Institution of Civil Engineers, that "Instead of the slimy coating of bluish-white matter that adheres to the crown and sides of the sewers, ventilated by openings in the roadways, there is a dryness for at least 100 feet on each side of the downcast shaft, and then a gradually increasing dampness is found until the upcast shafts are reached; at these points the crown and sides of the sewer are damp, but the moisture is clear compared with that of an ordinary sewer; the air passing out of the upcast shaft having a very slight smell of sewer gas." It should, perhaps, be noted, that the sewer where these experiments were made was a dead ended one, of large capacity in proportion to the work it had to perform, and that, therefore, the retarding action of the sewage flow upon the air currents was not considerable.

I am of opinion, that a more certain and reliable power than wind must be resorted to, for the purpose of diluting the air in sewers with fresh atmospheric air, and in securing continuous and regular air currents; and on this subject it is worthy of note, that sixteen years ago a Mr. Pettifer secured a patent, (now of course expired) for inducing a current of air, by a finely divided stream of water falling through a chamber to which air was admitted, and he states that the current of air may be employed amongst other purposes, for the ventilation of drains. As the result of recent experiments with ordinary rose jest (some of which were made in the presence of your President), I have no hesitation in saying that this method of introducing fresh air into sewers provided with

a special air passage, will be found reliable, cheap, and efficient, where water mains follow the routes of sewers.

These small jets of water consuming 15 to 20 gallons an hour, at the cost of a few pence only for each, for a day of twenty-four hours, can perform a threefold office, viz. the cooling of the air by its contact with the water; the introduction of volumes of that cooled air into the sewer, through the medium of the air passage; and finally the flushing of the sewer by means of automatic flushing tanks in connection with the manholes.

There are, however, various other sources of power by which air can be introduced into sewers, but I doubt whether there is any so economical, or so generally available, as that I have above referred to; one other I must, however, mention as being likely to be available in our large towns in the near future, and that is electricity.

You will, no doubt, have followed the recent strides towards the more general introduction of the electric light in towns, and I believe the time is not far distant when sanitary authorities, or electricity companies, will have their network of conduits running underground side by side with our sewers in our large towns, carrying power, capable of working fans to supply fresh air to the sewers, and regulating the air currents.

In conclusion, I may say that we confidently anticipate that the system of ventilation I have described, will bear the test of the practical experiments to which it will, we hope, be shortly submitted under the searching investigation of your able President, and other engineers, and I believe the time will come when municipal and sanitary engineers will consider the introduction of volumes of fresh cool air to mix with the sewer gases, inside the sewer an absolutely necessity, and when the volumes of fresh air and the air currents will be regulated upon a sound system, which will demand and receive as much attention at the hands of the responsible engineers as the proper working of the sewers themselves, and that such a system of ventilation will result in the prevention of many diseases to which the populations of our large towns are now subjected, owing to the present haphazard, and altogether unscientific and imperfect means resorted to for the ventilation of sewers.

DISCUSSION.

Mr. T. W. STAINTHORPE: As one of the youngest members of the Association present I have much pleasure in proposing a vote of thanks to Mr. Ford for his paper. This is a subject in which I have taken great interest for several years. I should just like to suggest that the list of experiments be published in the 'Minutes of our Proceedings,' and I should also like to ask Mr. Ford what quantity of water he used in conducting these experiments.

Mr. ELLICE CLARK: I have much pleasure in seconding the vote of thanks. Any contribution, or rather any thoughtful contribution to the question of the ventilation of sewers must be welcome to an Association of Sanitary Engineers. It is a subject which for many years has engrossed our attention. As you know, there is a Committee now sitting, which is collecting from the engineers of this country, America, Germany, and France, all the available data upon what is undoubtedly a very complex question. I do not agree entirely with everything that has been said in the paper, still while the question remains in its present unsatisfactory condition it cannot too often be discussed. I would just observe that in page 143 there is an allusion to some experiments made by the Chelsea Vestry in 1888, and if you will turn to the Proceedings of this Association for 1873 you will see a record of the same experiments being made with the same results. In passing, it should be mentioned we have subjects brought before us, which, if we had a good index of our 'Proceedings,' it would be seen had been discussed over and over again, and to-day we have been talking over one or two material points, especially in the first paper, which have been discussed—I was going to say *ad nauseam*—but have been discussed frequently. The patent which has been taken out by Mr. Harrington is in my opinion not a valid one, because I was the author of the proposal to ventilate sewers by an inlet air cowl. Any gentleman is perfectly at liberty to go and try that method of ventilating sewers. I tried the experiment referred to by Mr. Brooke of passing water in the ventilator of the sewer at Hove some years ago. The novelty about the present arrangement, if I understand it rightly, is having a pipe on the top of the sewer, containing a number of openings with an induced current, that will establish an air flow between the inlet water spray ventilator and the outlet, and that the air of the sewer will be

sucked up by the current through those small openings. If the author has tried the experiment and established it I have nothing to say, but my observations are opposed to the theory. I have been mostly engaged in seaside places, where the force of wind has more to do with the air currents in sewers than any other factor of disturbance. The intercepting sewer at Brighton is seven miles long, and parallel to the sea. You might have a gale from the north blowing at right angles to the sewer, and air stagnation in the sewer itself, but if you had a moderate current blowing parallel or nearly parallel to the sewer, there is established a draught in the direction of the wind, sometimes opposite to the waterflow, and sometimes in the direction of the waterflow. It will be very interesting to know if this partly old and partly new method is a success or not. We are exceedingly obliged to the author for his paper. Any solution of this vexed question will be warmly welcomed by Municipal Engineers.

Professor Robinson: I should like to ask if Mr. Ford has observed whether the air of the sewer is moved into the air passage by the action of an induced current. I have had something to do with air transmission and there is no reason why you should not have an induced flow. If you have a current of sufficient velocity you will get an induced flow as in the injector, but it involves the question of the transmission of air, the consideration of which cannot be gone into here.

The President: I think you are perfectly clear as to the method Mr. Ford proposes to adopt. I have been present on one or two occasions when the experiments were being tried by him, and I can vouch for some of the experiments, the results of which you see on that table. But the whole crux of this proposal for sewer ventilation is, will the air in passing along this tube at the top of the sewer, will the air passing at some velocity along that pipe induce the air of the sewer to follow it? That is the crux of the whole thing. I have asked my Corporation to allow me to spend a little money in trying this system on the sewers of the Corporation of Portsmouth. I think there is a great deal in it, but what will come of it I cannot say, but I hope on some future occasion to give the benefit of my experiments to the Association.

The vote of thanks to Mr. Ford having been adopted with applause,

Mr. Ford said in reply: I have to acknowledge this very kind vote of thanks you have passed to me and to express my apprecia-

tion of your attention to my paper. I have been asked first, what vertical drop was in the downtake pipe used in my experiments to introduce air into the air passage by means of a water jet. I have tried it with pipes, as shown by the diagram, 2 feet, 4 feet, and 6 feet, and found the result practically the same. With regard to the observation that there was no novelty in the Chelsea experiments, I had previously heard it suggested that the patent referred to had been anticipated, but if it be so, that does not depreciate the value of the experiments I referred to which showed the advantage of introducing fresh air. Professor Robinson has asked about an induced current. An induced current might be obtained, but in the application of the system as shown by the diagrams, we divide the sewers into sections by floating valves, and we compress the air of the sewer by forcing in the external air gently through the air passage by the action of the water jet; the cold air thus escapes from the openings in the air passage near the downtake shaft into the sewer, and the lighter and warmer air of the sewer is thus continually forced through the other openings near the uptake shaft, and into the open air. Experiments which I made with smoke rockets, at the suggestion of the President, showed that the current of air induced by water jets acted in the manner described.

IMPROVED JOINTS FOR SEWER PIPES.

By C. G. LAWSON, A.M.I.C.E., Southgate.

In commencing this the Author desires to draw your attention to the very valuable paper read by our newly-elected President at the District Meeting held in Brighton, March 15th, 1884.

The preliminary remarks for such a paper as this are so ably set out by Mr. Boulnois, that I may at once proceed to the description of the various joints proposed for discussion, illustrating them in alphabetical order.

I. Archer's Patent.
II. Doulton's Patent.
III. Hassall's Patent.

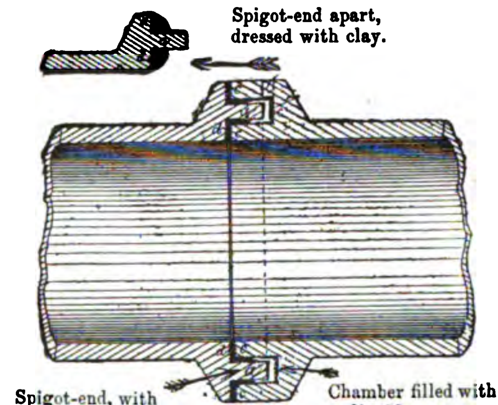
I. Archer's Patent.

This is described as "The Archer Patent Air and Watertight Sewer and Drain Pipe," and can be obtained from various manufacturers or licensees.

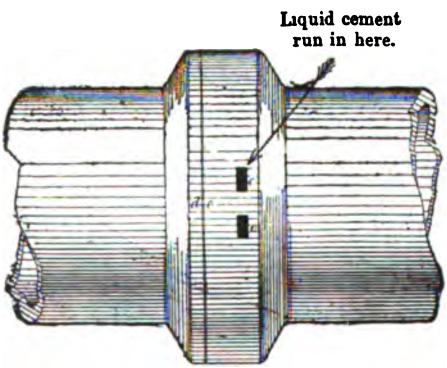
This joint is formed by constructing the sockets and spigots with a groove or double socket and tongue; the groove forms the socket, and the tongue the spigot. The tongue is made smaller than the groove, so as to obtain a chamber for the cement or such other material as may be used to run or complete the joint. On the socket of the pipe will be observed a pair of oval apertures, which are placed within about one inch of each other; these are used for running the jointing material, and must always be at the top.

The joint is formed outside the pipe proper, and in a manner quite different to that of the ordinary joint. On referring to the illustration or models you will observe that the socket is much thicker and deeper than usual, the spigot provided with shoulders and a bevolled bracket having its exterior flush with that of the socket. Until recently, the inventors had some difficulty in manufacturing the pipes in a single piece, but that is now over-

come, and when the pipe leaves the machine it is complete and ready for burning as you now see the specimens. The joint is made by standing the pipe spigot upwards on the ground or planks alongside the trench, and fixing fillets of well-tempered clay, not



SECTION.



TOP VIEW.

too rough, on each shoulder to a height or thickness of about half an inch, each ring of clay being thoroughly united as laid on. The pipe is lowered into the trench and the spigot forced into the socket of the pipe already laid; it must be well driven home by means of a block of wood and heavy mallet or levered up with an iron bar until the flanges nearly meet and portions of the clay are

forced outwards and inwards. If the pipes are very large they had better be very slightly slung during the latter operation. The interior of the pipe must then be examined, when it will be observed that the joint is supporting all round it thin fringes of clay. This is perfectly harmless and will soon be washed away or drop off. Having boned and ranged the pipe, also secured its position laterally, you may proceed with the laying of others, or complete the joint by fixing a piece of tempered clay under the division between the two holes so as to prevent the jointing material running both ways at one time. A double cup of clay is then formed round the holes similar to those used for running lead joints, so as to give the cement a head, and the joint is finished by pouring in a quantity of neat liquid cement or other material, which expels the air and gradually rises up the other opening, bringing with it any water that may be in the joint chamber.

Immediately afterwards tap the joint with a mallet to make sure no air bubbles have formed.

The cement joint has now assumed the shape of an annular channel] and forms a strong keyed joint.

If there is any defect in the joint it is readily proved by the cement not rising into the second opening but escaping inside or outside the socket. Such defects are rare, and easily remedied. If there is any difficulty in obtaining good clay, fine tough hair mortar will make an excellent substitute. By manipulating the clay cups, joints may be formed at any angle. The patentee claims for this joint equal utility for gas mains. Pipes with these joints are being manufactured in cast iron, and the Imperial Stone Company at Greenwich are now making a quantity of these joints on 18, 21, and 30-inch concrete tubes.

In the case of reconstructing a subsidiary main sewer, the author has recently laid some of these pipes in a trench which runs through some open reservoirs and in a valley adjoining a watercourse. Water came in the trench during the progress of the works, afterwards standing outside the pipes without entering or disturbing the same. Sewage was always admitted at the close of each day's work, without any extra pumping to pass same on, as in the case of ordinary pipes.

II. Doulton's Patent.

This is described as "Doulton's Patent Self-adjusting Joint," and is owned and produced by the well-known firm of Messrs. Henry Doulton & Co., Lambeth.

It is an artificial telescopic turned and bored joint, having the spigot so formed that the joint is capable of a little extension and deflection without affecting its watertightness.

The pipe is manufactured in the ordinary way and the joint afterwards applied. This operation may take place either at the manufactory or sewer works. The pipe is prepared by corrugations on the spigot and socket and the outside edges slightly chipped to increase the adhesion. The black material forming the joint is run on both spigot and socket by means of turned metal moulds, is a fusible composition, very hard, and capable of resisting ordinary atmospheric changes. Each portion of the joint is left with a clean smooth finish, so true that it is difficult to properly unite or separate the pipe unless a lubricant is used. Immediately the spigot is forced home in the socket the joint is perfect. The pipes are laid in the ordinary way, but care must be taken to prevent damage to the joints when being handled or shifted from place to place. A special lubricant in the form of grease is supplied with the pipes, but the author has tried and is of opinion that cold tar and paint are much better. No other joint is made as rapidly as these, and though somewhat flexible the same care must be used to keep the sewer in a straight line.

Pipes having this joint are very useful as temporary mains for conveying water or sewage across or under lands and roads of very uneven surfaces, and may be shifted for repeated use from place to place without injury to the joint.

III. Hassall's Joint.

This is described as "Hassall's Patent Safety Pipe Joint." It is apparently a combination, and not unlike a turned and bored joint with a cavity or annular chamber of rectangular section, formed by the grooves on the spigots and sockets of each pipe, afterwards filled with liquid cement, which really forms the joint.

The pipes for these joints are specially constructed, being made

with deep sockets, and the black composition similar to Doulton's and Stanford's. The spigots and sockets are each scored or combed so as to receive the composition; this operation can either be carried out at the manufactory or sewer works. The composition is run into moulds, which must be carefully centred, leaving the faces perfectly smooth and close fitting.

It will be observed that the composition is moulded with corresponding tapers on the spigot and socket, so as to form a dual joint and a chamber to enclose the cement.

Before being lowered into the trench each spigot and socket is painted with an oily plastic composition which acts as a lubricant, and fills up any space between the two joints, at the same time preventing the loss of any liquid cement. The pipes must be laid with the two holes in the socket upwards, and may be boned and ranged in the ordinary way.

When the spigot of the follower pipe has been forced or driven home, a small piece of tempered clay must be carefully fixed under the division between, and a double cup of clay formed round the two holes on the top of the pipe. The liquid cement or other jointing material is then run in one hole until it overflows the other, expelling air and any water that may have entered the joint chamber from the trench. As soon as the cement is run, the socket should be tapped with a mallet to make sure all air is brought to the surface, and the joint is complete.

The patentee asserts that the black composition is exceedingly strong and not liable to atmospheric changes or compression by heavy weights.

Conclusion.

The author has selected these joints as being worthy of consideration, and each possessing excellent qualities, besides being such as will facilitate the duties of the inspector or clerk of works, inasmuch as he can from the surface of the ground see the joints run and prove themselves good by the rising of the cement. In the case of the Doulton joint the inspection is a very simple matter.

Each member is advised to consider which joint is most suitable for his particular circumstances. If any manufacturer or patentee does not consider full justice has been done to him, or is desirous of supplementing the information, and is represented here,

no doubt the President will give him an opportunity of further enlightening the members of this Association.

Probably some member has expected this paper to include the Stanford joint; the author regrets that a joint which has apparently led to the invention of other improved joints upon such similar lines, could not be referred to as an improvement, but is of opinion that great credit is due to that inventor.

It is not desired to dispute that good work has been done in the past with joints made with cement and tarred gasket, sewers laid in concrete or puddle, and other inventions for special joints, but it is considered there is a necessity for a simple but satisfactory joint. The great consideration with special joints which may be termed ready-made is the cost thereof, but the engineer will find the real extra cost to be but small when compared with the actual cost per lineal yard of sewer executed, and certain to be quickly saved in working expenses. There is less cost of treatment of sewage, less liability of danger of pollution of subsoil water, and the sewers will carry more sewage.

In selecting watertight joints for sewers, the following points are advisable.

1. The joint should be in the hands of more than one or two manufacturers, so that a fair contract, as required by the Public Health Act, may be entered into.

2. The joint should not be liable to damage when in course of transit, or when being lowered into the trench.

3. The joint should be constructed so that the invert is always in a straight line, and able to be tested by a straight-edge.

4. The completion of the joint should be automatic and so simple that a good ordinary workman may be trusted to make the joint without having to adopt any unusual precautions, or the desired effect being dependent upon his extra careful manipulations.

5. If the joint can be prepared in stoneware the pipe must be moulded and burnt in one piece.

6. The joint should be of such a material that it cannot be affected by storage for any length of time, or be influenced by atmospheric changes.

7. The ends of all pipes should be concentric, even in thickness, and square to their axis.

8. Plenty of junctions should be inserted in the sewers, the stoppers fixed watertight so as to withstand internal pressures, and a strict rule enforced against any future displacement of the pipes

for a connection, unless a manhole bottom is formed, and that without disturbing the invert.

9. Pipe sewers are generally looked upon by contractors as very unimportant, but it is not so.

10. When laying pipes in running sand the same precautions should be taken to ensure a solid bed for pipes with special joints as for ordinary ones, or the joints will be injured.

11. All joints must be capable of being made when the pipe is partially under water, and those described in this paper can be so formed, and the water admitted immediately they are completed.

12. The joint must be capable of a ready inspection, and, if necessary to be run with cement, so arranged that a number may be quickly treated together.

13. If necessary the pipes must be selected, tested, sorted, fitted, and numbered on the surface.

14. In testing pipes do not put too great a strain upon those to be actually used. Select pipes from best clays only, and those known as stoneware or the nearest to it which are good bastards.

15. The cement used for running joints must not be new, and should be re-sifted before being mixed with the water.

16. The joint must be such that no roots can penetrate the sewer.

17. The joint must be capable of withstanding the hydraulic test of a small head of water within 36 hours after the joint has been run.

18. Unless sewers are laid in concrete, or the pipes made of cast iron, they should not be expected to work under a large head of water.

19. The joint must be capable of being completed at any angle.

20. The joint must be so formed that when the pipe is driven home the socket of the preceding pipe cannot be split.

In conclusion, the Author desires to point out that no matter what joint is used, the pipe should be secured in its final position before the joint is positively completed, so as to prevent any movement whatever, either horizontally, vertically, longitudinally, or laterally, which is sure to be the case if the bed of the pipe is packed with loose earth, just to make it bone correctly, and the subsequent filling round carelessly carried out. To meet this difficulty, when the pipes are not embedded in concrete, the author has for the past few years adopted with great satisfaction the plan of laying all pipes their full length, sockets included, upon a bed

of very coarse cement mortar, allowing the same to rise well up the haunches. The pipes used are in 2-foot 6-inch or 3-foot lengths, and wedges of earth inserted into each side between the pipe and the trench. All danger of fracture of the joint or sewer by the heavy weight of the refilled trench is avoided. The packing round the pipes is made with fine soil, and no lifting takes place by over-zealous ramming or influx of water. The cost for labour and material is very small compared with the benefits derived.

DISCUSSION.

Mr. W. Brooke: I have much pleasure in proposing a vote of thanks to the author for his paper. I remember something very similar to the joint (Archer's) when I was Assistant Engineer at Hove, Brighton; and I have asked a friend of mine to find out what the number of Archer's patent was, but he has been unable to find same. With Archer's joints I have just laid a length of 400 feet of 9-inch pipes, four of which broke off the socket of the preceding pipe when driven home. From the manner in which the sockets split, I should imagine the same had been fixed to the pipe after it had been made. I drew the patentee's attention to this, and he informed me they were making a different pipe now. As these pipes had only just been purchased, I did not see why I should not have the latest improvements; as they state the pipes are made differently now, this difficulty should not, of course, arise again. We had to condemn about fifty of the pipes. In consequence of the pressure in fixing the collar on the parent pipe, the pipe was forced out of shape, thus preventing the pipe being true inside; but the inventor tells me this failure has been rectified. I think it is as well to mention, as regards Hassall's joint, I have also used about 3 miles of that pipe in various sizes, and have found that, although we had as much as 8 feet of water to clear from the trenches, we made very fine and to all appearances water-tight sewers. The Archer joint, as well as Hassall's, is very quickly made, even by inexperienced workmen, and both make practically water-tight sewers.

Mr. Eayrs: I do not agree with Mr. Brooke in one of his remarks that we do not want sewers to go up and down. We want sewers to meet the circumstances of case. In a mining district like my own, where considerable subsidences take place, it is very

necessary to have pipes that should go up and down, though they generally go down.

Mr. H. J. Clarson: I should like to say a word about Hassall's patent pipes. I have seen several miles of them laid in a head of 7 feet of water, and seen them tested afterwards, when they were perfectly water-tight. I have now prepared a system of drainage for the place I represent, with these pipes, and there is no doubt they are the best pipes that you can use in a water-logged district. I have no doubt, from the test I have applied, they are the right pipes for us to use. I should recommend engineers in other towns in similar cases to use them also.

Mr. F. Smythe: I should like to ask the author if he has laid Archer's pipes with clay joints. Doulton's made some for me five years ago. I wanted a joint more flexible than cement would allow, and I struck the idea of Archer's joint. It was an idea which I did not carry out, for the reason that Doulton's entertained some difficulty in making them. I should like to know whether he has used any of these joints in clay. The difficulty I found with them was this: when the clay was filleted in all round the joint, and the socket came to be put in, the clay was jammed against the end of the socket when the pipe was pushed home into its proper place.

Mr. J. Lemon said: There is a good deal of credit due to the manufacturers and patentees for the joints that have been brought out. I have used most of these joints, and I must say, they are not so satisfactory as the patentees represent. I have used miles of the Stanford joint. You may set that joint on this floor and make it water-tight, but when you get it in a trench it is altogether different. I have lately used Doulton's joint in Portland cement concrete, but it is not water-tight. I gave an order only last night to have it taken up, and relaid with iron pipes. I have no doubt most of these joints are water-tight under special circumstances, when they are laid by experienced workmen on a ground like this floor, but when they are laid by labourers, even under supervision they are not satisfactory. I have come to the conclusion that the only sewer to lay in water is an iron pipe, and whenever I have any more sewers to lay in water I shall lay an iron pipe. I do not wish to deprecate any of these joints, but a great deal more has to be done if we are to get a water-tight joint.

Mr. J. Parker (Nottingham): May I ask you, Mr. Lemon, if you have used Hassall's patent joint?

Mr. Lemon: I must repeat what I have said, that I have not found any of them water-tight. I have not used Hassall's joint.

Mr. J. Parker (Nottingham): There are 15 miles of it at Hounslow, which is a water-tight sewer.

Mr. A. Ramsden: I think I can prove to any gentleman, or any member of this Association, that the Archer pipe is a water-tight pipe, and I shall be only too happy to test it in any way any member of the Association likes. The author states, with regard to the Doulton and the Hassall, that the black composition is not affected by the atmosphere; I find that is not the case, inasmuch as in a very hot sun the composition drops off, and I think there are members of this Association who will find it is correct that, during a very hot sun, the composition, which is composed of tar, sand, and sulphur, is affected in that way.

Professor Robinson: We are on rather ticklish ground with this paper. It is evident the interests of the patentees are coming in conflict in this discussion on the several forms of joints. The paper refers to Stanford, and the sequence in the paper puts Stanford last and Archer first. The order in which they should come is—Stanford, Hassall, Archer, and then the more recent one of Doulton. I had occasion to examine all these pipes, and report specially on them. I think the form of joint shown by Hassall had superiority over others. In a speech I made some months ago, I referred to these various joints and described the Archer joint as the *last* in the field, but the reporter misunderstood me, and made it the *best*. It has since been advertised that I gave it as my opinion that the Archer was the best, which I did not do.

Mr. Gordon: I quite agree that we are drifting on to delicate ground. I think it very undesirable that a controversy as to patents should take place in this room. We are all much obliged to Mr. Lawson for giving us the information, but when it comes to a question of patent pipes, or any sort of patents, I think we must confine ourselves to the results obtained by gentlemen using those pipes, because that is the sort of information that will be of use to the Association. If its influence is to prejudge the joints of any manufacturer, I think it would be better for gentlemen to give information as to joints as they have found them, and it should be left for gentlemen to go into the question of price with the makers of the particular joints they use. Every one of those joints have their respective merits, and if we are to begin to discuss the merits in the presence of the patentees, I am afraid we shall be rather

trenching upon the feelings of those gentlemen. I have used some of these joints, and I will tell you that the only fear I have in respect to them—and mind it is only a fear, I know of no failure of them at present—is as to the use of cement. Any joint made with cement requires the engineer to be careful that he does not get a contracting or expanding cement. Mr. Brooks referred to the failure of 400 feet of pipes at the point where the sockets were turned on to the pipe. But was there not the possibility of the cement being an expanding cement and so splitting the socket? I have made a good many experiments as to the expanding and contracting properties of cement, and have had many different cements the expansion of which has broken glass bottles and tubes used for the purpose of testing those qualities, and there is just the possibility, when cement is used for jointing, of its splitting the socket, if the cement happens to be of an expanding character. Apart from that there can be no doubt each of the special joints have their good properties. I am very pleased to hear Professor Robinson refer in very kind terms to the memory of the pioneer of these joints. It is to Mr. Stanford, whose memory many if us revere, that we owe the joint which paved the way for the inventive genius of others to follow on like lines, and to try to improve his joint. The Hassall and Doulton joints owe much to the labours and genius of Mr. Stanford. I hope nothing that is said with reference to these pipe joints will cause the manufacturers to think that we are doing either one or the other an injustice, or that we shall not be delighted for them to continue their efforts to effect further improvements.

Mr. Ellice-Clark: With regard to Archer's joint, if the patentee will go to the Hove Town-yard, he will see that joint was made for me eleven years ago. My object in designing it was to get a joint filled with asphalte, but I abandoned it because the asphalte got cold and would not run round the socket. I agree with Mr. Gordon that these particular patents may be used with advantage in different localities. There are certain places where of necessity you must go to a large expense to get an absolutely watertight sewer. I should be very sorry if anything that is said here to-day should lead the inventors to think we deprecate the improvements they are making. Nearly all the improvements that have been made in this respect have been made outside the profession of Municipal Engineers, who have not the time, or the same inducements as outside inventors have; and I think where men spend their time and

their capital—and a large amount of capital has been spent in producing these joints—they should be encouraged. I again express the hope that inventors, instead of having their efforts stopped by anything said here to-day, will know that engineers appreciate their efforts, and will be encouraged to believe that where a particular joint is required, engineers will use it without partiality to any individual.

The vote of thanks to the author was adopted with acclamation.

NOTES ON ELECTRIC LIGHTING.

BY E. J. SILCOCK, ASSOC.M.INST.C.E., ASSOC.INST.ELEC.ENG., BOROUGH ENGINEER, KING'S LYNN.

INTRODUCTORY.

SEVERAL papers on electric lighting appear in the 'Proceedings' of this Association, but they were, with one exception, all delivered by non-members, and the discussions which followed them were very meagre; this fact tends to show that the members generally did not on those occasions take that interest in the subject which it demanded.

As, however, electric lighting may now be said to have passed the experimental stage and reached the practical, and recent legislation, by extending the time before local authorities can compulsorily buy up the undertakings of private companies, has removed the only bar which for the last year or two has prevented capitalists from entering the field, this indifference should not be allowed to continue.

We may expect in the very near future that central lighting stations will be established in most of our large provincial towns as they are now being established in the metropolis and other places.

Our clients are in most cases interested either as a body or as private individuals in gas-works, and therefore it is probable that, in many towns, Corporations will not themselves run electric lighting stations; this, however, will not prevent private companies being started, as the Board of Trade has now power to grant Provisional Orders to Companies where Corporations refuse or neglect to undertake the work. These private companies will come into our midst, they will break up our streets, interfere with extensions of our sewers, drains, gas-pipes, and water-mains, and generally ride roughshod over public and private rights, unless they are duly restricted when obtaining their Parliamentary powers.

To whom, then, must our Corporations look to advise them in obtaining these proper restrictions? There is no official connected

with our municipal governments, except the borough engineer, who is at all competent to cope with this question; and undoubtedly it is the duty of every Member of the Association to make himself master of the subject, so that when the time comes we shall be able to advise our respective clients in this matter as we should do in any other engineering undertaking.

Our duties extend further than this: when once a Company is started in any town, one of the first places that the undertakers will seek to light will be our municipal buildings and streets, and the borough engineer will be called upon to design the consumer's part of the work of installation; and in some cases, where the Corporations take up the central station lighting themselves, we may be called upon to design the works of supply.

There is also another view of the question: the work of the profession is generally under-estimated; no doubt this arises from what is ignorantly deemed the ordinary nature of our work, and its want of special character. By adding to the duties of the borough engineer that of electric lighting, a natural addition to his work will be made which will be deemed extraordinary, and so to some extent act as a set-off against the want of appreciation in other respects.

The alternative to the borough engineer doing this work will be that electrical engineers will be called in, and we shall see a new department formed in our towns, the work of which should naturally, and will ultimately, come into our hands; the latter event, however, not taking place until the work has become ordinary, and all benefit from the introduction of the work has passed away.

This view of the question, together with the rapid strides which the science of electric lighting has made since the last paper was read, induced the author to bring the subject again before the Association. He does so with the feeling that the time to which he is limited is quite inadequate to cover all the ground; but as he has made a special study of the question, and passed an examination of the City and Guilds of London Institute, and had practical experience in the work, he deems it a duty at this juncture to give to the Association all the information he can upon the subject.

This he proposes to do by giving the following leading features and the particular points to be noted in electric lighting installations:—

Units of Production.

Before going into any detail of construction it may be well to say something as to the broad lines on which an installation is designed.

The first point to be considered is the number of lamps required, and here a word of warning must be said, viz. "be liberal."

The public generally expect more of electric light than they do of gas; they look upon electric lighting as something very brilliant, and if, in replacing gas, the same number of candle-power only is provided, the public will be disappointed.

Incandescent lamps are usually of 16-candle-power and 8-candle-power, but to avoid confusion we will consider all lamps to be 16-candle-power; each lamp requires about 50 to 55 watts of energy to supply it with light to give a fair life of say 1000 hours.

Arc lamps as a rule are made of 2000-candle-power nominal, but the actual available light is about half that amount; they usually take a current of 10 ampères at 45 volts potential to run them, or 450 watts.

We have now a means of determining the amount of power required for any installation: take the number of incandescent lamps and multiply by say 55, and the number of arc lamps multiplied by say 500, and the sum will be the total number of watts required.

Divide this total by 746, the number of watts in a horse-power, and we have the electrical horse-power which must be produced by the dynamos. To this must be added 10 to 15 per cent. loss in dynamos and mains, and we then get the aggregate brake horse-power which the engines must transmit to the dynamos.

Clearly for safe working this power must not be all concentrated in one engine and dynamo.

The next point therefore to be considered is the sizes of the engines and dynamos to produce this power, or the Producing Units, and this is a point which requires very careful consideration. As a rule it is best, as will be seen later, to keep arc lights and incandescent lamps separate, and to so arrange the units that there is always an engine and dynamo standing idle in case of a breakdown.

Assuming a case where 100 horse-power is required from the engines for incandescent lighting only; a good arrangement in such a case would be to have five engines and dynamos each

normally working 25 horse-power, but capable of giving off 33 horse-power if required, there would then be provision for a double break-down with only 25 per cent. more plant than actually required.

Engines.

High-speed engines coupled direct to the dynamo offer great advantages. They take up little room, and avoid all losses of transmission by belting or other methods of gearing.

Steam-engines are always to be preferred to any other form of motor in large installations, unless water-power is available, but good work can be done by gas-engines.

The most important point about the engine of whatever type it may be is that it shall be well governed. Electric lighting can never be successfully accomplished unless the engine runs at a perfectly uniform rate at all loads.

Engines are not unfrequently governed electrically, but there are several mechanical governors which are very satisfactory, and electrical engineers seem very divided in their opinion as to the advisability of using electrical governors.

Gas-engines are very convenient for small installations as they can be so readily started at a moment's notice, and can often be introduced into positions where steam-engines would be inadmissible; but for large installations, the gas-bill is too heavy in comparison with the coal-bill of a steam-engine. When gas-engines are used they should be provided with heavy fly-wheels, as should also the dynamos worked by them, and they should be worked as nearly at full power as practicable, as they run much more steadily with heavy loads than when running light.

Dynamos.

Dynamos may be said to be divided into three classes, known respectively as series, shunt, and compound-wound dynamos.

Series dynamos are used for arc lighting, and are so-called because the main current from the commutator is taken round the magnets and used as the exciting current.

Shunt dynamos are used for charging secondary batteries principally, and are so-called because the exciting current is a shunt taken off the main current on leaving the commutator.

Compound-wound dynamos are used for incandescent lighting; the term compound is applied because the magnet winding is

composed of two parts combining the windings of the two previous classes.

The principal difference in these three windings is that the series-winding produces a constant current, but the electromotive force can be varied by altering the speed of the engine. This is exactly the condition required for arc lamps, which are nearly always arranged in series. When, therefore, more lamps are put in circuit the electromotive force can be raised whilst still keeping the original current,

Shunt dynamos are used for charging batteries, because if the engine slows down and the electromotive force of the dynamos falls below that of the batteries, and the current is reversed in the armature, the electrification of the magnets is still such as to oppose an electromotive force to that of the batteries, thus preventing a sudden rush of current through the low resistance of the armature, which would be followed by burning of the armature winding.

Compound-wound dynamos are used for incandescent lighting. The object of the compounding is to keep a constant electromotive force with a varying current. Incandescent lamps are nearly always arranged in parallel, so that as more lamps are switched into circuit the current increases; but it is of the utmost importance to keep the electromotive force constant, as the effect of a very small rise of electromotive force on the lamps is very injurious.

Theoretically a compound-wound dynamo should give a constant electromotive force whether there is one lamp in circuit or the maximum number, but in practice it is usual to give a slight increase of electromotive force as the current increases to compensate for the resistance of the wires.

The most important point about a dynamo is its efficiency: there are several dynamos in the market to-day which give a commercial efficiency of 90 per cent. and even higher. It is a great mistake to economise to the extent of a few pounds in the first cost of a dynamo if that economy is at the expense of the efficiency.

And here a few words may be said in praise of electrical engineers. It is to their credit that machines can be purchased giving an efficiency of 93 and 94 per cent., that is to say, for every 100 horse-power transmitted to the dynamo from the engine 93 or 94 are returned in the shape of electrical energy

for utilisation outside the machine. It is only a few years since dynamos were first made commercially, and yet we have now in our hands machines which are more perfect than any other type of machine.

The turbine is perhaps the next most efficient machine, but the best turbines do not give more than 75 per cent. efficiency.

An instance of the rapid improvement in electrical machinery may be given. The author was connected with an installation put down in 1883, the dynamos of which were considered good at that time. They gave an efficiency of about 66 per cent., and to-day they are working side by side with dynamos which were delivered under contract to give an efficiency of 94 per cent.

The efficiency of a dynamo is measured by taking the electromotive force between the terminals with a voltmeter, and the number of ampères with an ammeter in the external circuit, these two quantities multiplied together and divided by 746 give the electrical horse-power in the external circuit; this quantity must then be compared with the brake horse-power delivered to the dynamo by the engine at the time the test is taken—the ratio of these two quantities gives the efficiency. These tests of efficiency should extend over various loads up to the maximum.

A further test should be made at full load for a period of not less than twelve hours, during which time the temperature of the magnet winding should be taken, and at the end of the run the temperature of the armature coils. As a rough test no part of the dynamo should ever be so hot that the hands cannot be pressed on it without inconvenience.

It is of course important to see that the bearings are large enough, well lubricated, and do not run hot, and there should be no sparking at the brushes.

Dynamos, if not coupled to the engine direct, should be fixed on wood frames, and it is convenient to have a screw and ratchet attachment to take up the slack of the belt.

In all cases the dynamo should be thoroughly insulated from earth, and the insulation of the magnet and armature coils should be as perfect as possible.

In specifying for dynamos, the type of winding should be given, and the output in ampères and volts, and the required standard of efficiency, instead of adopting the common method of specifying for a 100-light dynamo or a 500-light dynamo as the case may be. To speak of a dynamo as a hundred-lighter is all very well for

ordinary conversation, but it is quite a different thing to reject a dynamo as unsatisfactory if specified for in that way; it may be possible to light 100 lights with it in a way, but it is far better to make it quite clear what the output is to be.

High speeds are to be avoided in dynamos, as they occasion trouble with bearings, excessive wear on commutators and brushes, and heating and great mechanical stress in the armature winding, to say nothing of the necessity for small pulleys and tight belts, with the consequent loss of power by slipping and extra stresses put on bearings.

As a limit, perhaps 1000 revolutions per minute is as high as the speed should reach, and it is much better to have a larger machine, costing perhaps a little more and running at a slower speed.

It is important that dynamos should not be fixed in rooms where there is likely to be much dust, or where any "hazardous process" is carried on, or where any "hazardous goods" are stored.

The dynamo station should be well supplied with suitable meters. To every dynamo there should be an ammeter for measuring the current, and a voltmeter should be so arranged that the electromotive force of every circuit can be measured.

The dynamos and engines should be specified to run so steadily that a difference of potential amounting to $1\frac{1}{2}$ per cent. up or down should not be exceeded.

Wiring.

The wiring of an installation is somewhat analogous to designing a system of water-mains for a town supply. There are the main cables, which diminish in size as the branches are taken off, there are switches to cut out any branch or the whole supply, and there are safety valves in the shape of fuses.

All wires should be so proportioned that the current passing through them should never exceed 1000 ampères per square inch of sectional area of copper, and the difference of potential between the terminals of any two lamps should not exceed 4 per cent. the total electromotive force.

There should further be a relationship between the cost of conductors and the cost of power expended in overcoming their resistance. Sir W. Thomson's rule is that the interest and depreciation on the capital account for cables should be equal to the cost of the energy absorbed by their resistance.

The copper should be specified to have a conductivity of not less than 96 per cent. of pure copper.

The material forming the insulation is a somewhat vexed question. The class of cable mostly used consists of stranded copper wires tinned and wrapped in cotton. This is covered with three coats of vulcanised rubber. The cable is then braided with hemp and the whole immersed in a bituminous compound.

Guttapercha is used as an insulating material, but it is unsuitable for positions where the cable is liable to much change of temperature, as the guttapercha softens and the weight of the copper core causes decentralisation, which in time destroys the insulation entirely.

In cases where cables are to be laid underground, lead-covered cables are very useful, but they are liable to chemical action where they come in contact with vegetable acids.

Indiarubber is made of very different qualities, ranging from 1*s.* to 3*s.* per pound in price; it is therefore very necessary to be careful to specify that only the best quality of that material is used.

The following is the Admiralty test:—

Take a portion of the indiarubber and place it in a steam chest under a pressure of 60 lbs. of steam (about 300° F.), and keep it there for three hours. Remove, and put in a dry heat at 270° F. for two hours, and then allow to cool.

If the rubber is then soft and cools without cracking the quality is good. The chemical constitution should be specified and tested by analysis. The sulphur should never exceed 3 per cent., as it attacks copper very freely. The oxide of zinc need not be less than 40 per cent., and if used in a soil or for a purpose where it may be subjected to mineral oil, this oxide should be at least 60 per cent.

In testing for insulation two facts should be borne in mind, 1st, that a high initial insulation is no criterion of the durability of the material; and 2nd, that the insulation of the cables and of the installation as a whole are two very different quantities.

It is therefore very advisable to specify that the contractor shall stand by the insulation for as long as possible. Eminent electricians say five years is not too long.

The reason why the insulation of the installation as a whole and of the cables are distinct and separate is this, that there is often, especially in damp weather, a large amount of surface leakage

going on at fittings and joints which makes the insulation of the whole installation very low; now if this leakage, instead of being in the fittings, were chiefly in the cables it would show that they were very defective, and that a fault would occur in them sooner or later.

It is necessary, therefore, to test the cables before fixing, and Prof. Jamieson, of Glasgow, adopts the following rule, viz. one megohm per lamp for every volt, the coils being submerged in water not less than six hours, immediately before and during the tests; if the coils do not considerably exceed that minimum, they are subjected whilst in water to an electromotive force 50 per cent. greater than the proposed working electromotive force, and again tested.

The insulation resistance of the installation complete must be tested, and the same authority gives us the following rule—

$$R = K \frac{E}{N};$$

where R = resistance of insulation of circuit, or of generator in ohms,
K = a constant found by experiment from good examples = 100,000,
E = electromotive force of installation in volts,
N = number of lamps (16-candle-power) in circuit.

This gives us a value for the insulation of the circuit or of the generator, and therefore the insulation resistance of the two in parallel should be half that amount.

This test should be made after the trial run, when, if there should be any weak places in the insulation, the working potential will have had an opportunity of finding them out, and also the surface leakage from fittings, &c., will be at a minimum.

Great care must be taken to ensure good joints. Every joint should be made electrically and mechanically perfect. The two cables to be joined should be unstranded and interwoven one with another, then soldered, and then the insulation should be made good with proper insulating materials of the same class as those of the original cables.

In wiring public buildings it is advisable, if possible, to arrange the lamps on two circuits, in such a way that, should any accident take place, only half the lamps in each room will be extinguished, and this method lends itself to what is known as the three-wire

system, in which one of the main cables is a sort of intermediate cable doing duty for both dynamos, thus effecting an economy in first cost, and also in working expenses.

All cables inside buildings should, where possible, be laid in grooves ploughed in well-varnished boards, and where wires pass from one building to another, or through thick walls, they should be enclosed in cast-iron pipes; in no case should wires be buried in plaster.

The cables on leaving the dynamos should be all collected to a switch-board on which are placed the meters and suitable arrangement for switching the different dynamos on to the various circuits.

Every main cable, branch cable, and lamp, or group of lamps, should be provided with a switch for turning the current on and off, and with a safety fuse to prevent the current rising more than 25 per cent. above the normal current. All switches and fuses should be fixed on slate, porcelain, or other incombustible bases, and fuses should, if possible, be enclosed in incombustible boxes.

A revised set of rules for the fitting up of installations to prevent fire risks have been recently drawn up by the Institution of Electrical Engineers, and they should be incorporated in all specifications for contract work; but as several of the Fire Insurance Offices have rules of their own, it is necessary, if the buildings to be lighted are insured in one of those offices, to specify for their rules to be carried out in addition to those of the Institution of Electrical Engineers.

Lamps.

Incandescent lamps should, as a rule, be used for interior lighting. For large public rooms it is usually convenient to group the lamps together on chandeliers suspended from the ceiling; for lighting private houses, offices, reading rooms, &c., where the light must be concentrated in particular places, the lamps can be arranged in groups of two or three or singly, in the same manner as ordinary gas-burners.

Incandescent lamps are usually of 16 or 8-candle-power; although, as previously stated, people expect more of electric light than they do of gas, as a matter of practical experience the author has found that given a room or shop satisfactorily lighted with gas, which it is desirable to replace by reason of the injury to goods, decorations, health, &c., an 8-candle-power incandescent

lamp substituted for each gas-burner will equally light the premises.

The author found that a public reading-room 80 feet by 34 feet, lighted with 72 16-candle-power lamps in groups of three, equal 4·2 square yards per lamp, the lamps being 9 feet 3 inches above the floor, was not well lighted, also that another public reading-room 96 feet by 31 feet, lighted by 56 lamps fixed 8 feet 9 inches above the floor, equal 6 square yards per lamp, was well lighted.

This apparent contradiction could only be accounted for by the colour of the walls, in the former case the walls were of a dark green colour of encaustic tiles with a roof of dark brown and red mosaic, and in the latter the walls were cream colour and the ceiling dead white.

In a large public hall, 130 feet by 71 feet and 72 feet high, the author found that 7 electroliers, each bearing 56 16-candle-power lamps, at an average height of 30 feet above the floor, gave but a poor illumination; the same room was subsequently satisfactorily lighted in point of quantity of light with eight 2000-candle-power arc lamps.

In a recently built art gallery at Leeds lighted entirely by electricity, 16-candle-power lamps are placed in groups of four at 7 feet from the walls, in galleries 28 feet wide, and at a height from the floor of 8 feet 9 inches, and have been found very successful 5 feet 4 inches apart.

In galleries of the same dimensions groups of seven lamps, placed the same height from the floor and 6 feet apart, have also been found satisfactory.

Incandescent lamps are made of various resistances, requiring electromotive forces ranging from 40 to 100 volts. On installations of any size 100 volts lamps should be used. The lamps are always arranged in parallel, though occasionally they are arranged in parallels of two lamps in series.

Owing to recent litigation there is practically no choice of lamps in the market at the present time.

Lamps should never be run at a greater efficiency than 3 to 3·5 watts per candle, or the interior of the glass bulbs will soon become clouded by partial combustion of the filament, with a consequent loss of light, and the light of the lamp becomes shortened.

Incandescent lamps have been tried for street and out-door lighting and proved an utter failure; on the other hand, for such positions the arc lamp is most suitable.

For railway stations, covered markets, and similar places, the lamps may be suspended from the roof in convenient places, but always so high up that the lamps will not fall within the field of vision. In large open spaces the lamps may be suspended from masts.

In street lighting a 2000-candle-power arc lamp will light up a radius of 80 yards when placed over the centre of the street, but only two-thirds of that distance when placed against the buildings. The necessity for arc lights placed in the centre of the street being high enough to allow of the passing of a fire-escape is not of vital moment, as at most it will be only 25 feet, whereas the light is sufficient for 80 yards.

The renewal of the carbons in arc lamps has to be done every 16 or 32 hours. To do this readily in markets, railway stations, &c., the lamps should be suspended by electric leads passing over pulley blocks, to one of which should be attached a counterbalance weight, and the number of sheaves in the blocks be such that the weight will not fall below the lamp when in position.

For lamps suspended over the centres of streets the counterbalance weight can be arranged to run up and down the supports, and the cord for raising and lowering placed out of reach of foot passengers; the only inconvenience which arises from this method is the possible interference with traffic in crowded thoroughfares for the short time the attendant occupies in lowering the lamps and fixing the carbons, and that at most once a day.

The number of arc lamps in the market is legion, and great care must be taken in selecting a lamp which will give a steady light. Lamps should be focussing, and provided with an automatic cut-out, the regulating machinery should be simple, strong, not liable to get out of order, and well protected from the weather.

Arc lamps are nearly always arranged in series, the number on one circuit varying from 3 to 50, according to the electromotive force available. If the number of lamps in series be less than three, they will not run steadily unless a resistance is put in circuit as a sort of fly-wheel.

The author has found that one lamp will run with a resistance of 1·5 ohm in circuit, and two lamps with a resistance of 2·5 ohms. These resistances of course mean loss of energy, and they are therefore undesirable, but it often happens that arc lamps can be usefully employed on an incandescent system, and they can be made to run in that way.

Good carbons are a necessity for steady running, and the best results are obtained with cored positive carbons and solid negative carbons 13 mm. diameter.

Accumulators.

The principle of all accumulators is that a current is run through a battery composed of lead plates in an acid solution, when oxide of lead is transferred from the positive plates to the negative, making them at a higher potential than the positive plates. We have then mechanical energy transformed into electrical energy, which in its turn is transformed into chemical energy, in which form it can be stored and reproduced when required in the form of electrical energy.

This double transformation from electrical energy to chemical and from chemical to electrical, causes a certain amount of loss, and probably it may be stated without being wide of the mark, that on an average 30 per cent. of the energy will be lost, or, in other words, that the efficiency of secondary batteries as a rule does not exceed 70 per cent.; this loss, combined with their large cost and the trouble which they occasion, does much to prevent the general adoption of secondary batteries, but they offer great advantages in reducing the number of hours a dynamo has to work at small loads, and in reducing the size of the dynamos and engines. The light from an accumulator is absolutely steady, and consequently incandescent lamps have an increased length of life when run from them.

In cases where power is available during certain hours of the day, or where a small water power is constantly available, secondary batteries can be used with advantage, as it is then possible to utilise at night the power which would otherwise be lost, and they form a great feature in one system of central lighting.

Secondary batteries should be very carefully put up, and means adopted to prevent creeping of the acid, which causes leakage.

Central Lighting.

The central lighting of towns may be effected in one of three ways, which may be briefly described as follows:—

1. *Direct Supply.*—This system consists of laying down mains (which should be on the three wire-system) from a central station and supplying each house direct with the current. The potential in such a case cannot well exceed 200 volts, and the large cost of the distributing mains makes it practical only for supplying

districts within a radius of half a mile from the generating station. This system is adopted by the St. James and Pall Mall Company, and the Bradford Corporation.

2. *Transformer System.*—By this system an alternating current is generated at a central station, and conveyed at a high potential varying from 2000 to 10,000 volts to transformers at various points in the districts to be supplied. The transformers reduce the electromotive force to 100 volts, and the current is proportionally increased; the current is then distributed to the houses as in the first method. This system is adopted by the London Company, the Metropolitan Company, the House to House Company, the Eastbourne Company, and others.

3. *The Accumulator System.*—By this system a continuous current at high potential, of from 1000 to 2000 volts, is generated at a central station, and conveyed to distributing stations, where it is used to charge accumulators. The current is then distributed from these accumulator stations at about 100 volts. This system is used by the Chelsea Company, and the Kensington and Knightsbridge Companies, and will be used by the Notting Hill and Westminster Companies.

The relative merits of these three systems are not finally settled, but it may be said that the direct supply system is practically limited to small towns, or to the more densely populated parts of large towns. For the supply of large towns from one station, or for sparsely populated districts, either the transformer or accumulator systems must be adopted.

The arguments for and against these latter systems are very concisely summed up by Major Cardew, in the report of Major Marindin to the Board of Trade, published in *The Electrician* of May 24th, 1889, from which the following is extracted:—

"The transformer system carries the high pressure up to the houses. The distributing mains, therefore, are of small size. A large district can be served from one station, and the regulation of pressure in the distributing mains can be very good. There should be no great difficulty in maintaining a standard pressure within a variation of 2 per cent. The pressure in the houses may be different in different cases, according to the needs or fancy of the consumer.

"It is also a simple system to work, and the dynamos are simple, and can be made in easily replaceable parts.

"On the other hand, the high pressure necessitates great care

and expense in insulation; the conveying of this high pressure to, at any rate, one point on the consumer's premises, and the risk of a contact between this circuit and the low-pressure circuit inside the house, involves some risk to life, although it may be reduced to a minimum by proper regulations and precautions; the main cannot be handled or connections made when the pressure is on; the regulation in the houses is not so good as in the mains, as the transformers act as a considerable added resistance, and cause an increased variation of pressure in the power as compared with that in the mains; the system cannot at present be efficiently utilised for motive power, or for electric deposition or other chemical uses, such as charging accumulators; and it is very doubtful whether a practically successful alternating motor is likely to be brought out; the system depends entirely on running machinery, and engines and dynamos have to be kept in motion throughout the 24 hours; the general efficiency must be low when the supply is near its minimum, a condition which, so long as it is utilised for lighting alone, obtains during about 18 hours of every day on the average, and a serious accident in the generating station might stop the supply for a considerable time. Alternating machines cannot be so readily connected together to run in parallel circuit as continuous current machines. The measurement of alternating current, pressure, and power also offers considerable difficulty, and the available instruments and methods are far more restricted in number than is the case with the corresponding quantities in continuous supply.

"The Chelsea (Accumulator) system has the advantage of high pressure between the generating and distributing stations, without its being brought into the consumer's premises, and the distributing stations may be so numerous that each one serves only a small district, and in this way the size of distributing mains may be kept down; the supply from batteries has these enormous advantages: that in the event of a total breakdown at the generating station supply can still be maintained for some hours; that it is not necessary to keep the machinery at the generating station in motion throughout the whole 24 hours, and that the batteries provide a supply for the long hours when very little is required; the system has the advantages of continuous currents, viz. applicability to the supply of motive power, and other uses besides light and heat, and greater ease of measurement. The regulation, with small areas supplied from each sub-station, should be very good, and there is no

doubt that a battery current is less destructive to lamps than one supplied from dynamos, whether alternating or continuous.

"On the other hand, the cost of the batteries is very great, and they require skilled attention, while their efficiency at maximum output is probably rather low; the automatic switches are a weak point, and any failure in this action would probably ruin the batteries at that station; the insulation of large batteries cannot be maintained at all high, and the numerous joints, in the presence of acid fumes, are a source of weakness.

"This system, in which the supply is entirely from accumulators, if it can be successfully worked in practice, possesses very great advantages."

Two defects are mentioned by Major Cardew in the transformer system, viz. that alternating dynamos cannot be run in parallel, and that no successful alternating motor is likely to be brought out.

The author ventures to think that these two difficulties are overcome, and that if Major Cardew were writing his remarks to-day, he would not name them.

All distributing cables should be laid underground. Many forms of conduit have been devised for the purpose of protecting the cables, but probably nothing will be ultimately used but ordinary cast-iron pipes. In the Bradford installation the cables are simply laid in the ground and covered with boards.

Where cables are laid in conduits they should be insulated with vulcanised rubber, as condensation is certain to take place inside the conduit, and if the wires are not insulated leakage will take place, but lead-covered cables are unnecessary where conduits are provided: they are adopted in some installations without conduits; in such cases they should be sheathed in iron to prevent mechanical injury.

Time does not permit of descriptions of the meters used for measuring the current used by each house; but it should be taken as a principle that meters should be used, and not an annual charge per lamp.

Cost.

The cost of installations of electric light varies very much, but it may be useful to the members to give them some actual figures of cost.

An installation of about 2000 16-candle-power incandescent lamps, supplied direct from dynamos driven by steam engines

designed and erected by Mr. T. Hewson, M.I.C.E., Borough Engineer of Leeds, for the Leeds Corporation, cost in round numbers 50*s.* per lamp, including boilers, iron chimney, engines, dynamos, cables, lamps and fixing.

Central stations vary even more than home installations, but an installation of 37,500 lamps, 10-candle-power, for Leeds, including site, buildings, chimney, engines, dynamos, cables, transformers, and meters, will cost about 30*s.* per lamp; the plant to be capable of supplying two-thirds of the total number of lamps at one time with the necessary surplus power. This will leave the consumers to supply their own wiring, lamps and fittings, as in the case of gas, and this will probably cost 1*l.* per lamp unless very expensive fittings are used.

The cost of working at Leeds, Mr. Hewson finds, comes out at $\frac{1}{4}d.$ per 16-candle-power lamp per hour, and probably a 10-candle-power lamp can be supplied from a central station at the rate of $\frac{1}{8}d.$ per hour, without profit, but including interest and depreciation.

In the metropolitan area it is proposed to charge on a sliding scale at a maximum price of 8*d.* per Board of Trade Unit (1000 watt hours). This will probably mean that the consumer of large quantities will be charged about 6*d.* per unit, which is equivalent to gas at 3*s.* 9*d.* per 1000 cubic feet. To this must be added the renewals of lamps, which, taking 1000 hours as the average life, makes the cost of electric lighting equivalent to gas at 4*s.* 6*d.* per 1000 cubic feet to the consumer.

The cost of running 2000 candle-power arc lamps may, perhaps, be put down at $2\frac{1}{2}d.$ per lamp per hour, to cover all charges, but not make a profit.

Three years since electricity cost the consumer over an equivalent of gas at 7*s.* per 1000 cubic feet. The reduction in the price of gas from its introduction was not by any means so rapid as that of electric lighting has thus been, and apart from the certainty of further development in the art of electric lighting, the lapse of patents alone (of which so many now fetter the work) will in a few years reduce the price far lower than it is to-day.

Conclusion.

Leaving the scientific aspects of the question, the author commends to the Association the following conclusions:

That by reason of a Corporation being able to borrow money at

a cheaper rate than would be deemed a satisfactory profit to a company, and that it need not make a profit, it can supply electric light to its ratepayers far cheaper than a paying company could.

That any future discovery in electric lighting which would produce it more cheaply, would, for long periods, benefit the shareholders of a company only, revisions in the price being at intervals of perhaps ten years.

That the principle of keeping entire possession of the streets is one which, the experience of all towns, in regard to tramways, gas, and water companies has taught them, should never be yielded.

That although a local authority may agree with a company to light a town for a shorter time than the forty-two years named in the Act of Parliament, a company would only agree to this on receiving advantages equivalent to them to the reduction in time.

Again reminding the Association that the capitalist has been let loose, and that the Board of Trade will grant provisional orders to companies where the Corporation neglect or delay to undertake the work, the author concludes with the hope that the interest of the members may be aroused, that they will rise to the occasion, and that the information contained in his paper will be of use to them in dealing with the question.

DISCUSSION.

Mr. MacBrair: I should like to ask Mr. Silcock whether we can, with the arc system, get the same regularity of light that we get with the incandescent. The author says "the regulating machinery should be simple, strong, and not liable to get out of order." I should like to ask whether the fluctuating of the light does not come from the machinery getting out of order.

Mr. Eachus: I should like to ask a question as to the failure of the incandescent light. We tried incandescent lamps, for a month in conjunction with a rclamps, and the conclusion we arrived at after trying them was, that incandescent lamps of 60 candle-power were the most suitable form for street lighting. Perhaps the author will be good enough to tell us something of these failures. I should like also to ask for the equivalent to the Board of Trade unit in lamps of 16 candle-power.

Professor Robinson: I should like to add my meed of praise to the author for the excellent paper he has brought before the

meeting. As you paid me the courtesy of inviting me here to-day, I may add to the interest of the meeting by asking your acceptance of a report on electric lighting which I prepared for the St. Pancras Vestry. For that report I prepared a great number of calculations, over the ground covered by the author, in the form of figures and tables. I am very pleased to-day to have been able to contribute something to the meeting. Putting it broadly, I calculate that any authority can produce electricity at 4¼*d.* per Board of Trade unit, paying off the cost of works in 42 years, while the companies have the power to charge 8*d.* per Board of Trade unit.

Mr. Lobley: I quite agree with the author as to the failure of the incandescent lamp for street lighting. In the spring of last year a great many of us met at Leamington. We saw the lighting of Leamington by the incandescent lamp. I believe the light has been abandoned since then; but at the time we visited Leamington, there was nothing in the light to strike us as being a success. Some of us have also seen it in Holborn, and it is very much the same there. With regard to arc lights, a great many of the members were at Hanley, and saw the experiment tried there; an experiment which proved a success so far as there being no flickering in the light. We also conclusively proved that we could light by the arc light, for the same price as for gas. The difficulty—and it is a difficulty which I am not aware has been overcome—in carrying out arc lighting is in small streets, and places where that light is too large. We cannot replace half a dozen street lamps, and put in one arc lamp; we found we could not make 100 arc lamps do the work of 700 gas lamps. Where the arc lamp was used, it proved a perfect success in the large open spaces where several gas lamps could be dispensed with.

Mr. J. Lemon: I desire first of all to thank Professor Robinson for his report. I cannot agree with some of the conclusions of the paper read by Mr. Silcock, although I agree we are much indebted to him for having given us so much information. At the outset he says "These private companies will come into our midst, they will break up our streets, interfere with extensions of our sewers, drains, gaspipes, and water-mains, and generally ride rough shod over public and private rights." Well now that is a most sweeping condemnation. All I can say is that I have lately been concerned in framing regulations against a company in Southampton, and the only thing that astonished me was that the company allowed themselves to be so tied down with restrictions;

and so far from riding rough shod over the Corporation, it is the other way about. Our friend is another example of the ardent engineer who wants to do everything himself. He also advocates that all Borough Engineers should be electrical engineers. Now I do not. They would all like to do it perhaps, but I think they have got quite enough to do at present, and I do not think they could do it so successfully as the man who has made an entire study of it. The time may come when they will have to become electrical engineers, but that is not at present. I think a great deal has to be done with electricity before it can compete with gas in price. According to the figures given by the author, it will be about 4*s.* 6*d.* as compared with a thousand feet of gas. We know there are many towns where gas is being supplied for less than half that price, and therefore there is a good deal to be done before we can compete with gas as to price alone. The electric light has many advantages over gas, and I believe it will be adopted in place of gas in public buildings, but I do not believe it will be adopted generally in competition with gas for small houses and general purposes. I believe we shall see very great improvements in electric lighting and a reduction in the cost.

The PRESIDENT: I am sure every member present thanks Mr. Silcock for a paper on a question which to us is a novelty. I believe the Borough Engineer is waiting to see what is the outcome of this electric question. He cannot spare the time to follow the working of a new profession to him, for it is very rare in any town to find that the Borough Engineer is gas engineer as well. The question whether this work shall be put on the town official must receive great consideration before we adopt it.

The thanks of the Association were accorded to Mr. Silcock for his paper, with acclamation; and the President, in the name of the Association, thanked Professor Robinson for his report.

Mr. SILCOCK, in reply, said: We want to select the simple arc lamps which give a good result and are not likely to get out of order. As to whether incandescent lamps for street lighting are a failure or not, I can only quote two cases—Barnet and Leamington. The principal cause why they must be a failure at the present time is that incandescent lamps cannot compete with gas in point of price, whereas arc lamps can. Each Board of Trade unit will keep from 18 to 20 lamps running for one hour, and 4½*d.* per unit is about the cost of production of energy. Well, then as to Mr. Lemon's remarks as to private companies, I am

afraid I trod on somebody's toes. I am very sorry, but my opinion stills runs in the direction stated in my paper. Look at the railway companies, the water companies, and the gas companies. What have they done? They have blocked up your streets with pipes, and arches, and bridges. There is no doubt companies have in the past disregarded the convenience and rights of the public to a very great extent, and we have no reason to suppose that electric lighting companies will be different to other companies. I am strongly of opinion that the lighting of all towns should be in the hands of the Municipal Authorities, and on that ground only we shall do well if we can keep companies out.

On Thursday several Members inspected the New Town Hall Works. In the evening the Members dined together at the Victoria Hall; among the Visitors were the Mayor of Portsmouth, Sir Frederick Bramwell, Bart., F.R.S., Sir Wm. King, Ex-Mayor, Capt. Warren, R.N., Major-General Stirling, C.B., R.A., Lieut.-Col. Galt, Col. Lanyon Owen, Mr. J. S. Smith (Local Government Board Inspector), &c.

On Friday morning the Members of the Association assembled at the Dockyard, for the purpose of inspecting the Fleet and the workshops. The Members were met at the Dockyard gates by Lieut. Grant, of H. M.'s torpedo ship 'Vernon,' and Lieut. Ethelstone, who conducted them through the yards to the North Corner, taking on the way glimpses at the various vessels which, with modern haste, are being pushed forward on the various slips, and the numerous completed torpedo boats in vicinity to the dockyard. Arrived at the North Corner, the Members embarked on a large troop boat, and were towed to H.M.'s ship 'Vernon,' which perhaps more than any other ship in the service tells the story of modern scientific warfare. The varied application of electricity to modern warfare, as shown by the numerous experiments made in the lecture-room, was scanned with keen and scientific interest, and a short trip by an electrical pinnace, which is steered and controlled from the directing vessel, without any person being on board, was watched with close interest, The torpedo room, with its stock of murderous instruments, was also an object of much interest. The Naval Authorities, with a view of giving their engineering visitors the fullest knowledge of naval warfare, showed by experiments the method of breaking a boom defence with torpedo boats, the mode of clearing a mined channel by means of counter mines and outrigger booms, and the

manner of blowing up a boom. The Members were then conducted to Whale Island, where experiments were made with the Maxim, Nordenfelt, and Gardner quick-firing machine guns. It is worthy of mention that the single-barrel Maxim gun fired 334 *shots at a range of* 300 *yards in the incredibly brief period of half a minute After luncheon which was served at the Victoria Hall, and at which Lieuts. Ethelstone and Grant attended as guests of the Association. the Members viewed the new ironclad 'Collingwood,' which is armed with four* 45-*ton guns, and went a pleasant run in a first class torpedo boat round the Spit Fort. On Saturday the Members visited, in brakes kindly provided by the President, the Ferrumite (patent paving stone) Works, and were shown specimens of the Company's manufacture, which were exceedingly well laid. The Members then proceeded to the works of the Portsmouth Water Company, situate at Havant. In the admirable report prepared by Sir Robert Rawlinson, C.B., M.I.C.E., it is stated that the geology of the site is a substratum of chalk covered by alluvium of a mixed character, loam, clay, gravel, and marl. The water is obtained from natural springs, which rise to the surface and overflow, passing, when not intercepted, into the sea. The volume of water taken at present is about five million gallons per day. After an inspection of the works, the Members were entertained at luncheon by the Directors, in the New Engine House, Lieut.-Col. Galt presiding. After luncheon, Lieut.-Col. Galt started the new engine, which, on the suggestion of the President of the Association (Mr. Boulnois), was christened the "Galt" Engine.*

APPENDIX.

SEWAG LEICESTER.

if so, hov any othe	give the number of men ed to work the Farm ?	Do you apply the raw sewage to the land, or is any part treated chemically beforehand ?
.	.. .. ..	Sewage treated with sulphate of alumina and lime previously.
d com cent. on	and 5 boys	Sewage is applied in its raw state.
of horse s.	200	Treated with lime.
k ..	anager and six work- (excluding Farm let).	No; by lime process.
emolu-	e 65 to 70	Raw sewage applied to land.
annum emolu-	29 in winter to 34 in est time.	Yes; no part is chemically treated beforehand.
has use and orwood lary of re no hed to	gton averages 30 ; South Norwood ges 10 men.	The sewage passes through screens to remove the solids; there is no chemical treatment whatever.

Do you apply the raw sewage to the land, or is any part treated chemically beforehand?

Raw. We do not treat it chemically; it is unnecessary in our case.

In every case the sewage is applied to the land in its crude state, without any preparation.

Sewage is purified direct from town to farm; no chemical treatment.

Only raw sewage.

y pay nothing for it, and the

Farm is not the property of
and reclaimed from the beach,
f comparison, as our position

Town or Distri
NORTHAMPTON .. .. (W. IBBS BROWN, *Boroug*
NORWICH .. .. (P. P. MARSHALL, *City 1*
NOTTINGHAM .. .. (ARTHUR BROWN, *Borougl*
OXFORD .. .. .. (W. H. WHITE, *Engineer Local Board.*)
RUGBY .. .. .. (WM. STEWART, *Surveyor.*)
TUNBRIDGE WELLS .. (R. BRENTNALL, *Surveyor.*)
WARWICK .. .. (E. MELVILLE RICHARDS, *I Engineer.*)

vided with a e free of cost?	Please to give the acreage of Farm, and state whether the sewage is applied to the whole of it.	What kind of subsoil does the Farm consist of down to a depth say of 6 ft. from the surface?	Can s
iliff has a nce on the , free of	The acreage of the Farm is 207 acres, and sewage is applied to practically the whole of it.	The subsoil is a sandy clay.	E
in a house e Farm.	73 acres, all irrigated ..	Clay, except 16 acres, which is of gravel, &c.	75
n excellent , and in it large Com- e-room.	330 acres. Can't get the sewage on to all the land, but we hope to do so soon.	Every conceivable subsoil, stiff clay, gravel, sand, and peat.	D
.. ..	84 acres, of which about half is arable, and this receives most of the sewage.	Drift gravel with small beds of clay here and there.	Al

... it become slippery ?	Do you approve generally of concrete pavement ?
...ore than some flags ..	Yes.
. .. .	Yes.
... .	No; much prefer York or Lancashire flagging.
...ade too hard and with ... materials.	Yes; if well done.
... .	Yes.
... do not	No; but prefer it to York flagging.
...ain extent, but as now ... is not so slippery as it	Am inclined to approve of it in slabs but not *in situ*.
... .	Yes.
...ularly; on very steep ...s it should be grooved ...ered.	Yes; especially Stuart's Granolithic.
... .	No.

Does it become slippery?	Do you approve generally of concrete pavement?
Yes	No; solely on account of its slipperiness in streets of steep gradients.
Not to any appreciable extent ..	Yes; but prefer *situ* paving in widths to slabs.
On steep gradients	Think disadvantages outweigh advantages.
Some of it does	Yes; of some kinds.
No	Yes.
No; if made with fine materials	Yes.
No	Yes.
No; except on very steep gradients.	Yes.
If laid with too much slope, rather slippery in frosty weather.	Yes; though possessing certain advantages, do not think it will supersede York flags.
No	Yes.

the ... yard, ... t become slippery?	Do you approve generally of concrete pavement?
s.	Yes.
.. ..	Yes; if laid on good foundation.
olusi	Yes.
olusi ... ation	Most certainly; have not purchased flags for several years and do not intend to.
.. perly made	Yes; especially for suburban roads.
.. ed to in wet weather, ... ow made it does not.	Yes.
.. ..	Yes; in slabs.
.. perly laid	Yes; it is the best paving out.
ind. ... ation	Yes.

R

Further Remarks.

10

r annum received by sale of
als, and is credited to the
t.

portion of city unprovided
eceptacles; ashes removed
-cart service.

pressing on to one uniform
and abolishing the privy,
e emptying of ashbins will
e in daytime.
verting privies into water-
at the rate of about 250 a

erience is, that the work is
out very much more effi-
by our own staff, and at a
t, say about 25 per cent.
rage cost of emptying each
during the year 1888 was at
e of 2*s*. 8*d*.

I am able to obtain 1*s*. per
r nightsoil, which farmers
their own cost.
osal of the refuse results in
which is included in the
given.

f consists of 8 men and 4
; realise nearly 100*l*. per
by sale of nightsoil.

VOLUNTARY EXAMINATIONS.

SYLLABUS.

The Association of Municipal and Sanitary Engineers and Surveyors have undertaken the holding of Voluntary Pass Examinations for Candidates for Surveyorships under Municipal Corporations and the Local Government Acts.

There will be two Examinations in each year, one in April, and one in October, in London.

The Examinations will be by written papers and *viva voce*, upon the four following subjects:—

1st. Engineering as applied to Municipal Work.
2nd. Building Construction and Materials.
3rd. Sanitary Science as applied to Towns and Buildings.
4th. Public Health Acts, and Rivers Pollution Acts.

Examples of the class of questions proposed to be asked under these heads are appended hereto.

Candidates will be allowed two hours to answer the questions under each of the four heads, and will not necessarily be required to answer all the questions set in each paper, though not less than four must be taken: marks will be given for all questions properly answered. The *viva voce* examination will be held after the written papers have all been sent in, and will be directed to the further elucidation of the answers to the papers on each subject, and to such practical points as fairly arise therefrom.

The Examinations will extend over one or two days, as circumstances may require, and in the latter case the arrangements will be, as far as possible, as follows:—

First day ..	10	to 12	..	Engineering.
" ..	2	" 4	..	Building Construction.
" ..	5	" 7	..	Sanitary Science.
Second day ..	9.30	" 11.30		Public Health Law.
" ..	1	" 4	..	*Viva voce* Examination.

The total number of marks required to constitute a pass will be 50 per cent. in each of the subjects.

Each candidate has to fill a Form of Application, to be obtained from the Secretary.

The fee for each Examination will be 3*l.* 3*s.*, one guinea to be paid on application, and the balance on the day of examination. Should the candidate fail, he will be entitled to present himself again at the next, or any subsequent Examination, on payment of one-half of the above fee.

No further charge will be made to the candidate than the fees above mentioned.

Candidates that do not present themselves for the Examination forfeit the entrance fee.

Successful candidates will be entitled to receive a Certificate in the form of a "Testamur," signed by the Examiners for the time being, and countersigned by the President and Secretary of the Association in Council.

Further details and particulars may be obtained on application to Mr. Thos. Cole, Secretary to the Association, 11, Victoria Street, S.W.

SUBJECTS OF EXAMINATION.

I.—Engineering as applied to Municipal Work:

A. Land Surveying and Levelling.
B. Hydraulics.
C. Drainage and Sewerage.
D. Water Supply.
E. Road Making.

II.—Building Construction: Strength of Materials:

A. Materials.
B. The Construction of Public and Private Buildings.
C. Building Bye-laws.

III.—Sanitary Science as applied to Towns and Buildings:

A. Ventilation.
B. Sewage Disposal.
C. House Drainage.

IV.—Public Health Acts.
Rivers Pollution Acts.

SIXTH EXAMINATION.

The Sixth Examination of candidates was held at the Institution of Civil Engineers, Westminster, on the 26th and 27th October, 1888, at which the following Examination Papers were set to the candidates.

SUBJECT:—ENGINEERING AS APPLIED TO MUNICIPAL WORK.

Examiner:—H. Percy Boulnois, M. Inst. C.E.

1. *Surveying.*—(*a*) How would you measure the distance of an inaccessible point with the chain only? (*b*) Describe the method of setting out a right angle with the chain.
2. Explain the "Wells" system for measuring distances with an ordinary dumpy level without the aid of a chain or tape.
3. *Levelling.*—A sewer has a fall of 1 in 375·75, the reduced level at its lower end is - 2·05, what would be the reduced level at a distance of 300 yards up the gradient?
4. *Hydraulics.*—What velocity constitutes a self-cleansing flow in a 12-inch pipe sewer, what gradient is necessary to effect this with the sewer running half full, and what proportion does the diameter of sewer bear to its velocity of flow?
5. Describe the process of gauging the flow of water through the V notch.
6. *Drainage and Sewerage.*—Give the essential requisites for a good system of house drainage. Make a sketch of an intercepting trap with manhole and fresh-air inlet, &c.
7. Describe the precautions that are necessary in the selection of a sea outfall. What are the disadvantages of tide-locked sewers, and how can they be remedied?
8. *Water Supply.*—Give a sketch section of an ordinary sand filter bed for a town water supply of about 30,000 inhabitants, and state how many square yards of filtering area are necessary and the rate at which the water should pass through the filter.
9. Describe a "Positive Meter," "Ball Hydrant," "Straight" and "Bent Ferrule," "Ground Stop Cock," "Bib Cock," "Ball Cock," "Back Pressure Valve," and "Safety Valve."
10. *Road Making.*—(*a*) What contour would you give to a macadamised roadway, (*b*) what cross fall to the footwalks if paved with asphalte, (*c*) what proportionate width should footpaths bear to roadways, (*d*) what proportionate width should the paved channel bear to a macadamised roadway?
11. Give a sketch section of a kerb, channel, and trapped gully pit.
12. Give a list of the principal materials which can be used for paving footpaths and state which you prefer, and your reasons for such preference.

Subject:—Building Construction, &c.

Examiner:—Clement Dunscombe, M.A., M. Inst. C.E.

1. State briefly the general principles to be observed in building with stone and with brick to ensure good work.
2. Describe the following classes of stone masonry: ashlar, block-in course, coursed rubble, and common rubble.
3. What is the difference between coniferous and non-coniferous timber? classify each, and give examples, and state the respective purposes for which each description is most suitable.
4. State at what age of maturity the following trees attain their greatest strength and durability, viz. oak, ash, elm, larch, and fir; the best season for felling them; and the modes adopted for seasoning timber.
5. Describe shortly, and illustrate by a sketch, how you would shore up a dangerous building, 50 feet in height, fronting a main thoroughfare, and having a frontage thereto of 30 feet, assuming that the front wall is in danger of falling towards the street.
6. Define the following terms referred to in the Model Building Bye-laws:—base of wall, topmost story, party wall, external wall, public building, building of the warehouse class, domestic building, dwelling house.
7. What are the requirements of the Model Bye-laws with respect to the sufficiency of space about buildings, to secure a free circulation of air, and with respect to the ventilation of buildings?
8. Draw a sketch plan and section of a temporary small-pox hospital, with its accessories, for six patients, constructed in either wood and corrugated iron or wood and Willesden paper; figure thereon floor area and cubical space; describe the preparation of the site, and specify shortly for the respective materials used in its construction and internal finish.
9. What regulations would you propose for the arrangement, construction, and structural working of a new theatre on the safest lines, selecting your own site and dealing with the subject under the following heads:—1st. The means of egress. 2nd. The prevention and isolation of fire. 3rd. The lighting arrangements.

Subject:—Sanitary Science.

Examiner:—Lewis Angell, Fellow King's Coll. Lond., M. Inst. C.E., Examiner under the Metropolitan Building Act.

1. State, in general terms, the chemical condition of the atmosphere in an overcrowded and ill-ventilated room. In what manner does it act on the physical system?
2. How many cubic feet of air space should be allowed, per head, in a bedroom?

3. In what manner may drinking-water become contaminated in a dwelling-house?
   What constructive arrangements are necessary to prevent such contamination?
4. What are the requirements of the Model Bye-laws with regard to house drainage?
   Give a sectional diagram of a three-storey house in illustration, showing the drainage thereof connected with a street sewer.
5. What tests would you apply to house drains to discover any escape of sewer gas?
6. What are the leading principles in the design of a system of town drainage, of say 50,000 population, having a free river outfall:
   I. In a flat district?
   II. In a hilly district?
7. What principles govern the ventilation of sewers, and what relation thereto has temperature, gradient, capacity, and volume of flow?
8. Enumerate the best-known processes of sewage treatment at the outfall, and describe some one in detail, stating, in technical terms, the mechanical and chemical method of procedure and results.
9. State under what respective circumstances a tank process, irrigation, land filtration, or a combination of either, may be most desirable.
10. Describe the difference, in principle and action, between irrigation and filtration.

SUBJECT:—PUBLIC HEALTH ACTS AND RIVERS POLLUTION ACTS.

Examiner:—C. Jones, A.M. Inst. C.E.

1. The Public Health Act is divided into several parts. State how many, and give the names of six divisions.
2. Give the titles of the several Acts of Parliament incorporated with the Public Health Act.
3. A Local Authority having undertaken to remove refuse, &c., (*a*) state the provision of the Act dealing with their neglect of this duty, (*b*) The number of days specified in the Act as involving a penalty, (*c*) The penalty incurred.
4. State generally the process set forth in the Act for the repairing of private streets, and under what section private streets may be declared "to be repairable by the inhabitants at large."
5. Give the definition in Act as to "What is to be deemed a new building?"
6. State the surveyor's legal duties and position with respect to ruinous or dangerous buildings, and the title of the incorporated Act under which proceedings are taken.
7. State the proceedings to be taken by a Local Authority in dealing with a nuisance *outside* the district.
8. State shortly the "General Provision" of the Act with reference to contracts.

Ten candidates presented themselves for examination, of whom the following six satisfied the Examiners, and were granted their certificates of competency:—

R. R. Brown (Bridlington).	I. T. Hawkins (Chichester).
W. G. Bryning (Liverpool).	J. S. Millington (Wavertree).
W. C. Field (Eastbourne).	T. B. Wilson (Cockermouth).

SEVENTH EXAMINATION.

The Seventh Examination was held at the Institution of Civil Engineers, Westminster, S.W., on the 29th and 30th March, 1889, when the following Examination Papers were set to the Candidates.

Subject:—Engineering as applied to Municipal Work.

Examiner:—Lewis Angell, M. Inst. C.E., Fellow King's Coll., London, Examiner under the Metropolitan Building Act.

1. In a Town Survey, having selected three points forming a well-conditioned triangle, one side a, b, being available for chaining a Base line, the lines a, c and b, c being visible but inaccessible for direct measurement, show how you would ascertain the lengths a, c, and b, c, and formulate the process trigonometrically.

2. Describe the principle of the Vernier and how it is read.

3. In a series of levels, if the first backsight read 3·25 on an Ordnance Bench-mark of 28·30, the sum of the backsights be 12·95 and the foresights 17·20, what will be the Ordnance reading of the last foresight?

4. What is the weight of one cubic foot of water? What is the resulting pressure per square inch in a tank or reservoir for each foot vertically below the surface? At what depth is the centre of gravity situate.

5. What is meant by the hydraulic mean depth of a sewer?

6. Describe the methods of ascertaining the quantity discharged from a sewer.

7. What relation has size to gradient in a sewer?

8. Make a figured sketch of a combined manhole and ventilator, also a cross section of a brick oviform sewer, showing vertical and transverse diameters length of radii and position of centres.

9. Write a specification clause for a concrete sewer, with proportions and tests.

10. Give a sketch of the construction of a brick sewer, 15 feet deep, in running sand, 5 feet from the top being made ground and the next 4 feet peat. Show method of foundation and timbering.

11. Describe the leading principles in the construction and maintenance of roads, and specify (*a*) a Granite paved road, (*b*) a Macadam road, (*c*) a Gravel road.

12. Give a working sketch of a cross section of a 40-feet gravel road, with footpaths, formed on a field, in accordance with the requirements of the 150th Section of the Public Health Act.

Subject :—Building Construction, &c.

Examiner :—Clement Dunscombe, M.A., M. Inst. C.E.

1. Classify according to their characteristic "earthy" constituents the different kinds of stone used in building and engineering works; state the predominant minerals existing in them, and give examples in each class, and for what works they are respectively used.

2. Define the meaning of the term "bond" in brickwork.
   What are the effects of a good bond?
   Explain the following terms:—
   A "course," a "bat," "headers," "stretchers," "closers," "Queen closers," "King closers."
   State the different kinds of bond used in brickwork, and their relative merits.

3. Draw plans and sections of two or more courses of 9-inch and 14-inch brick walls in two different bonds in the case of detached walls and salient angles.

4. What principles would guide you in designing joints and fastenings in Carpentry?
   Illustrate by sketches the mode of jointing beams in the direction of their length by "lapping," "fishing," and "scarfing," and in the last case so as best to resist Cross-strain, Tension, Compression.

5. Explain the following terms and illustrate by sketches,—"stuck bead," "planted bead," "quirked bead," "staff bead," "cocked bead," "reeding," "nosing," "stop-chamfer," "housing," "scribing," "shooting," "rebating," "trimming."

6. State the quality, weight, and thickness of lead you would use for the following purposes:—Aprons, Roofs, Flats and Gutters, Hips and Ridges.

7. Draw a plan and section of a fireproof warehouse, 40 feet frontage by 60 feet in depth, 5 storeys in height, and with concrete floors designed to carry 2½ cwt. to the foot superficial; figure on the thickness of the walls, and give the constructional details of the floors; specify for the concrete forming the floors, and state what precautions you would adopt for the prevention of fire in connection with the construction of such building.

8. Draw up a Specification in skeleton for Artizans' or Labourers' Dwelling built in brickwork or stone with a slated roof—first giving the various headings of the Specification, and, so far as time permits, enlarging under the various trades.
9. Draw a sketch plan of the arrangement of rooms and sanitary conveniences you would suggest in the case of 2 and 3 roomed tenement Dwellings in flats for the housing of the poor, and give an approximate estimate of the cost per room of given floor space and cubical capacity, all sanitary conveniences and appurtenances to be included in this cost.

SUBJECT:—SANITARY SCIENCE.

Examiner:—H. Percy Boulnois, M. Inst. C.E.

1. *Ventilation.*—State the requisite amount of cubic space per head required in the following buildings:
   (*a*) A bedroom in a Model Lodging-house.
   (*b*) A ward in a Fever Hospital.
   (*c*) An accident ward in a Hospital.
   (*d*) A workroom in a Factory.
   (*e*) A cowshed [under the Contagious Diseases Animals Act, 1878].
   (*f*) A cellar dwelling.
   (*g*) A barrack dormitory.
2. How many cubic feet of fresh air per hour should be admitted in a room 20 feet square and 10 feet high, where there are 15 adults and 5 lighted gas jets, each consuming 5 cubic feet of gas per hour.
3. What are the essential requisites to be remembered in supplying the necessary quantity of fresh air to the above room.
4. State the fixed law of the "diffusion of gases."
5. *Sewage Disposal.*—Give a list of the different methods of Sewage Disposal under the "Dry" and "Water Carriage" Systems.
6. State the principal ingredients of the sewage of an inland manufacturing town sewered on the Water Carriage System.
7. Give a brief description of any chemical method of sewage purification with which you are acquainted, and state its advantages and defects.
8. Give a sketch section of a "Fryer's" Refuse Destructor, and state what heat is necessary to destroy "sludge."
9. *House Drainage.*—Describe the thickness, jointing, method of fastening, and other details for a soil pipe carried against the outside wall of a house, accompanying your description with detail sketches.
10. Give a longitudinal section of a bath, showing the supply pipes for hot and cold water, and the waste and overflow, and show where the hot water tank should be situated.
11. State briefly the essential requirements of a perfect system of House Drainage.
12. What is the reason for ventilating a soil pipe?

SUBJECT:—PUBLIC HEALTH ACTS AND RIVERS POLLUTION ACTS.

Examiner:—Charles Jones, A. M. Inst. C.E.

1. What are the powers of an Urban Sanitary Authority with respect to the draining of houses into new sewers?
2. A local authority may undertake the cleansing of streets and removal of refuse. Detail:
   (*a*) The general authority contained in the 42nd section upon the above subject.
   (*b*) The disposal of material collected and disposal of fund.
   (*c*) Penalty imposed upon persons obstructing authority in carrying out the above section.
3. (*a*) State the requirements of the Act with respect to a Local Authority supplying water to certain houses in their district.
   (*b*) Proceedings authorised to be taken under the Act.
4. Describe generally the conditions laid down in the Public Health Act with respect to the occupation of existing cellar dwellings.
5. Section 91 has special reference to nuisances under the Act. State how many clauses there are; and give detailed definition of nuisances.
6. Describe the power possessed by an Urban Sanitary Authority with respect to the alteration of any gas or water pipes laid in the district, and the provision relative to the expenses incurred in such alteration.
7. By the 157th section of the Public Health Act every Urban Sanitary Authority has power to make bye-laws respecting new buildings. These powers are detailed under four distinct headings. Give general description under each heading.

Eighteen candidates presented themselves, for examination, of whom the following eight satisfied the Examiners, and were granted their certificates of competency.

J. H. Blizard (Southampton).	H. Nettleton (Leeds).
J. W. Bradley (Burnley).	W. Stringfellow (Southampton).
G. F. Carter (Leeds).	W. J. Taylor (Southampton).
W. B. Dixon (Wolverhampton).	G. B. Tomes (Eastbourne).

BOARD OF EXAMINERS.

Lewis Angell, M. Inst. C.E., F.R.I.B.A., Borough Engineer, West Ham (Past President).

H. P. Boulnois, M. Inst. C.E., Borough Engineer, Portsmouth (President).

C. Dunscombe, M.A., M. Inst. C.E., City Engineer, Liverpool (Vice-President).

E. B. Ellice-Clark, M. Inst. C.E., County Surveyor, West Sussex (Past President).

Joseph Gordon, M. Inst. C.E., Chief Engineer, London County Council (Past President).

C. Jones, Assoc. M. Inst. C.E., Surveyor to the Local Board, Ealing, W. (Past President).

W. G. Laws, M. Inst. C.E., City Engineer, Newcastle-on-Tyne (Past President).

Jas. Lemon, M. Inst. C.E., F.R.I.B.A., Consulting Engineer, Southampton (Past President).

Jos. Lobley, M. Inst. C.E., Borough Engineer, Hanley (Past President).

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R. Vawser, M. Inst. C.E., Manchester (Past President).

W. H. White, M. Inst. C.E., Engineer to the Local Board, Oxford (Past President).

CANDIDATES WHO HAVE PASSED THE EXAMINATION.

Date of Certificate.		
May 7, 1887	..	Adcock, C. (Liverpool).
May 1, 1886	..	Angell, J. A. (Leytonstone).
May 1, 1886	..	Ashmead, H. (Clifton).
Oct. 16, 1886	..	Ball, G. (Scarborough).
May 12, 1888	..	Barnes, S. W. J. (Ealing).
May 12, 1888	..	Bayley G. H. (Salford).
Oct. 16, 1886	..	Beard, E. T. (Lincoln).
May 12, 1888	..	Beynon, J. C. S. (Exeter).
Apr. 13, 1889	..	Blizard, J. H. (Southampton).
Apr. 13, 1889	..	Bradley, J. W. (Burnley).
Nov. 17, 1888	..	Brown, R. R. (Bridlington Quay).
Oct. 16, 1886	..	Brownridge, C. (Leeds).
May 12, 1888	..	Bryans, J. G. (Sunderland).
Nov. 17, 1888	..	Bryning W. G. (Liverpool).
Apr. 13, 1889	..	Carter G. F. (Leeds).
May 1, 1886	..	Coales, H. G. (King's Lynn).
Oct. 22, 1887	..	Cook, J. (Bury).
May 12, 1888	..	Cooper, C. H. (Wimbledon).
May 7, 1887	..	Cooper, F. E. (Liverpool).
May 12, 1888	..	Crow, A. (Stratford, E.).
Oct. 16, 1886	..	Crowther, J. A. (Leeds).
May 7, 1887	..	Dearden, Hy. (Leeds).
Apr. 13, 1889	..	Dixon, W. B. (Wolverhampton).
May 1, 1886	..	Fenton, W. C. (Sheffield).
Nov. 17, 1888	..	Field, W. C. (Eastbourne).
May 12, 1888	..	Finch, A. R. (Finchley).
May 7, 1887	..	Franks, T. W. (West Bromwich).
May 12, 1888	..	Glass, S. N. (Hackney).
May 12, 1888	..	Gloyne, R. M. (Manchester).
May 1, 1886	..	Greatorex, A. D. (Toxteth Park).
May 1, 1886	..	Harland, A. (London).
Nov. 17, 1888	..	Hawkins, I. T. (Chichester).

Date of Certificate.		
May 12, 1888	..	Houghton, J. (King's Heath).
Oct. 16, 1886	..	Jameson, M. W. (Leeds).
May 12, 1888	..	Lynam, G. T. (Barnsley).
Oct. 16, 1886	..	Mallinson, T. (Selby).
Oct. 22, 1887	..	Mellor, T. E. W. (Stockton).
Oct. 22, 1887	..	Metcalf, J. W. (York).
Nov. 17, 1888	..	Millington, J. S. (Wavertree).
May 12, 1888	..	Milnes, G. P. (Wakefield).
Apr. 13, 1889	..	Nettleton, H. (Leeds).
May 7, 1887	..	Nichols, A. E. (Leeds).
May 7, 1887	..	Nickols, F. J. (Leeds).
May 1, 1886	..	Osborne, F. (Dover).
Oct. 22, 1887	..	Parker, W. (Hereford).
Oct. 16, 1886	..	Pickering, J. S. (West Bromwich).
May 12, 1888	..	Pritchard, T. (Richmond).
May 7, 1887	..	Rich, E. W. (Hounslow).
May 1, 1886	..	Saunders, E. E. (Walthamstow).
May 7, 1887	..	Saunders, Jas. (Newark).
Oct. 22, 1887	..	Saville, R. W. S. (Accrington).
Oct. 16, 1886	..	Silcock, E. J. (Leeds).
Apr. 13, 1889	..	Stringfellow, W. (Southampton).
Oct. 16, 1886	..	Sykes, E. (Reddish).
Apr. 13, 1889	..	Taylor, W. J. (Southampton).
Oct. 16, 1886	..	Thomas, R. J. (Carnarvon).
Apr. 13, 1889	..	Tomes, G. B. (Eastbourne).
Oct. 16, 1886	..	Turner, V. H. (Leeds).
May 7, 1887	..	Verschoyle, B. (Liverpool).
Oct. 22, 1888	..	Ward, F. D. (Manchester).
May 12, 1888	..	Wilson, C. L. W. (Bacup).
Nov. 17, 1888	..	Wilson, J. B. (Cockermouth).
May 1, 1886	..	Witts, J. W. (Skelton).
Oct. 16, 1886	..	Young, Wm. (Pendleton).

Memoirs of Deceased Members.

The Council, having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

THOMAS CRUSE, born on the 20th of April, 1809, was the eldest son of Jeremiah Cruse, of Horningsham, Wilts, Conveyancer to the Marquess of Bath, of Longleat, and grandson of Jeremiah Cruse, of Bath, Land Surveyor, who was for some years in partnership with William Smith (the Father of English Geology.)

He was educated at Warminster, and articled to John Brown, Land Surveyor and Estate Agent, of Brislington, near Bristol, for whom he afterwards acted as assistant for several years, making some important Parish Surveys.

He afterwards returned to Warminster and entered into partnership with his brother-in-law, Charles James Fox, during which time he made a considerable number of Railway Surveys, and made the Surveys and First Class Tithe Maps of the parishes of Warminster, Corsley, Upton-Scudamore, Horningsham, Longbridge Deverill, and North Bradley, in Wiltshire, and Frome-Selwood and Cheddar in Somersetshire.

He was Surveyor to the Warminster Turnpike Commissioners for nearly 30 years, and Surveyor to the Warminster District Urban Sanitary Authority until 1887, when he resigned in consequence of failing health.

He held the Office of Vestry Clerk until the day of his death,

May 3rd, 1888, having been struck down with angina pectoris ten days prior to that date.

The other deaths are Mr. BATTEN, of Handsworth, near Birmingham; Mr. HARPUR, the Surveyor to the Local Board, Merthyr Tydvil; Mr. MILES, Surveyor to the Rural Sanitary Authority, Blaby; and Mr. RUMBLE, Surveyor to the Local Board, New Barnet.

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